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The Milk River: International Lifeline of the Hi-Line

Educators Guide

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Milk River International Alliance

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International WET Water Education for Teachers

Montana Fish, Wildlife & Parks

SPORT FISH RESTORATION

The Milk River: International Lifeline of the Hi-Line Educators Guide

Only when we understand the heritage of the land, and are able to interpret that heritage, does a real sense of place become possible.

Tom Wessels
Into the Field: A Guide to Locally Focused Teaching

In January 1998, 39 residents of the Milk River Watershed gathered to plan a symposium for area residents titled "Know Your Watershed, the Milk." Participants agreed that basin residents needed a better understanding of the Milk River Watershed. With that in mind, plans were made to develop a video to serve as an enduring source of information and education about the Milk River.

Later that year, with assistance from Milk River water users, tribes, agencies and citizen groups, a video titled *The Milk River: International Lifeline of the Hi-Line* was produced. It tells the story of the Milk River Watershed and its importance to agriculture, municipalities, wildlife, and recreation in northern Montana and southern Canada. The video made its debut in Havre, Montana in January 1999 at the symposium, "Know Your Watershed, the Milk." This workshop brought together, in a unique meeting of minds, over 200 basin residents interested in natural resources conservation and public education. One theme flowed through the entire meeting—collaboration and coordination were the keys to improving water management in the basin. From that theme, the Milk River International Alliance, an international citizen-based watershed group, was born.

To promote education and outreach in the basin, the Milk River International Alliance Video Subcommittee formed with the goal of developing a set of educational supplements to elaborate on the concepts covered in the video. In October of 2000, 15 Milk River area educators took up part of this challenge and gathered for a weekend of brainstorming, writing, and collaboration. This book, entitled *The Milk River: International Lifeline to the Hi-Line, Educators Guide* is the result of that effort. In it you will find high quality, regionally relevant activities that illustrate watershed concepts, explore human influences and dependence on the watershed, examine principles of water conservation, and much more. A companion book entitled *The Milk River: International Lifeline of the Hi-Line, A Guidebook* provides background information, resources and contact information for many of the topics covered in this publication. Together the video and these books provide a unique and powerful set of tools for learning about the Milk.

It is my sincere hope that you find this collection of resources useful and inspiring, and that in them you will discover a basis for extended study and appreciation of the Milk River region in your classroom.

Sincerely,

Carol L. Elliot

Carol Elliot
Superintendent
Blaine County Schools, Chinook, MT

Acknowledgments

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Bureau of Reclamation, Montana Area Office
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Valley County Conservation District
Chinook Eagles Ladies Auxiliary #689

The Milk River Alliance

The Milk River International Alliance is a citizen-based watershed group working to understand the Milk River Watershed, and to be a positive voice for the effective management and enhancement of the resources on which we all depend. Through the Alliance, basin residents and natural resource managers are working together to craft local solutions to natural resource issues within the basin. The term "international" highlights the importance of the basin to citizens on both sides of the international boundary. The Alliance is open to all U.S., Canadian, and Native American basin residents who wish to participate.

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Map
A black line map of the Milk River Watershed suitable for copying into handouts and overheads appears in the centerfold of this book.

Using this Book

This book is designed for use with the video, *The Milk River: International Lifeline of the Hi-Line* and *The Milk River: International Lifeline of the Hi-Line, A Guidebook.* To order any of these materials please contact:

Project WET
201 Culbertson Hall
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Or contact your local Conservation District.

Pre-Video Discussion Questions:

K-4 Grade Levels

1. What are the headwaters of a river?
2. Who uses water from the Milk River? How do they use it?
3. How do you and your family use the water of the Milk River?

5-8 Grade Levels

1. The title of the video is *The Milk River: International Lifeline of the Hi-Line.* What is a lifeline? How is the Milk River considered a lifeline?
2. What is a watershed?
3. Who do you believe uses the most water from the Milk River? Who uses the least? Explain your answers.

9-12 Grade Levels

1. What is a watershed? What defines its boundaries?
2. What types of water management problems exist on the Milk River?
3. How are these problems addressed?
4. What skills are needed to solve natural resource problems? How would these skills be used in the Milk River Watershed?

Post-Video Discussion:

K-4 Grade Levels

1. Where does the Milk River begin? Where does it end?
2. Does the river receive different amounts of rain and snow at its headwaters than at other reaches of the river?
3. What uses of the Milk River does the video describe? What uses do people make of the river?
4. How are Lewis and Clark significant to the Milk River?
5. The video explains that the river flows for 700 miles. However, a plane can fly from the Milk's headwaters to its confluence with the Missouri in only 300 miles. How can you explain this difference?

5-8 Grade Levels

1. The video explains that the river flows for 700 miles. However, a plane can fly from the Milk's headwaters to its confluence with the Missouri in only 300 miles. How can you explain this difference? Does this suggest that the Milk River is a young river or an old river?
2. Generally, how often does drought occur on the Milk River?
3. When was the largest flood of the Milk River? How has the management of the Milk River since then helped prevent flooding?
4. How is water carried from the St. Mary's River into the Milk River? Is it "fair" to divert one river into another?
5. Which Canadian provinces does the Milk River flow through?
6. Were concerns of American farmers similar to those of Canadians?
7. How is the Milk River a boost to the Hi-Line's economy?

9-12 Grade Levels

1. What is the single greatest use of the water from the Milk River and its tributaries?
2. What treaty between Canada and the United States reduces conflict over the Milk River's valuable water supply?
3. What is the role of a "ditch rider?"
4. If you were manager of the Milk River during a particularly dry year, how would you manage the water? Would you distribute water evenly, or would you shut down supply to some users? Why?
5. Give examples of the different types of irrigation used in the Milk River Watershed.

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Picture a River

Grade Level:
Upper Elementary, Middle School

Subject Areas:
Art, Language Arts, Social Studies, Earth Science

Duration:
Preparation time: 20 minutes
Activity time: 50 to 100 minutes

Setting:
Classroom

Skills:
Gather, Analyze, Interpret, Compare and Contrast, Present

Vocabulary:
Continental Divide, characteristics, headwaters, tributary, watershed

Summary

Students learn the story of two boys who explore the length of a river with their grandfather. Students then compare and contrast the characteristics of the Milk River with those of the river in the book.

Objectives

Students will:

- identify the characteristics of a river.
- compare and contrast the features of the Milk River with other rivers.

Materials

- A copy of the book *Where the River Begins* by Thomas Locker
- Drawing paper
- Pencils, crayons, paints

Background

The Milk River begins as small rushing headwaters streams combine high in the mountains of Glacier National Park. As it moves toward the prairie it flows through areas of both steep and slow gradient, through tight spaces and wide-open landscapes. It eventually flows from Montana, into Canada, and back to Montana on its way to join the Missouri River 700-miles from where it began. This activity will encourage students to imagine what it would be like to take a journey along the Milk River from their home to the headwaters on the Continental Divide. Students will also think about how rivers change as they move downstream, and what natural and human factors can influence them. As you read *Where the River Begins* students may comment that the river in the book is different than the Milk River. Ask them to pay special attention to the features of the stream such as its rocks, vegetation, shape and the surrounding landscape. Regardless of their location, rivers share many characteristics and the river in the book may be more similar to the Milk than they think.

Procedure

Warm Up

Read the book *Where the River Begins* to your class without showing the illustrations. When finished, have students discuss what they think the different sections of the river described in the book might look like. What did the river look like near Josh and Aaron's house? What did the river look like where Josh and Aaron camped the first night with their grandfather? What did the headwaters of the river look like? Have students use as many descriptive words as they can. Now, read the book again. This time show the illustrations to the students as you read. How closely do their descriptions match the images found in the book?

The Activity

1. **Divide students into small groups. Have them brainstorm and write down answers to the following question: What are some characteristics of a river?**
2. **Some characteristics students might describe include:**
   - Rivers carry water
   - Rivers start small and grow larger
   - Rivers have rocks
   - Rivers have bends and turns
   - Rivers have stretches of rapids and stretches of calm
   - Rivers have many plants and trees growing along them
   - Rivers have logs and branches in them
   - Rivers sometimes flood
   - Rivers attract wildlife
   - Rivers eventually flow to the sea
   - Etc.
3. **Have groups report their answers to the class.**
4. **Compare and contrast the river in the book with the Milk River.** Where do students think the book takes place? Why? Do the landscapes of the two rivers differ? Does the Milk River have all of the characteristics they described in their lists?
5. **Have students paint or draw a scene of the Milk River in a style similar to the illustrations in the book.** They may choose to illustrate any place along the river, in any season. Ask them to share their illustrations with the class when they are finished.
6. **Make a list of similarities found in all students' pictures.** Some things in common might include: vegetation lining the banks of the river, rocks or branches in the river, wildlife, influences of man (buildings, farms, etc.), or the surrounding landscape.
7. **Repeat the brainstorming session of the characteristics of a river. Compare this list with the original list students made.** After drawing or painting a picture of the Milk River, students should be able to describe many more river features.

Wrap Up

Discuss conclusions the students have reached about rivers. Discuss differences between the headwaters of a river and areas further downstream.

Assessment

Have students:

- describe the characteristics of a river (steps 1,2,7).
- describe the similarities and the differences between the Milk River and the river in *Where the River Begins* (steps 4,5).

Extensions

Have students work individually or in small groups to make a book titled *Where the Milk River Begins*. Have them use the pictures they made during the activity. They may use text from *Where the River Begins* or create their own.

Give students drawings by other students and ask them to write a story about what life would be like in that scene. They can make the story as adventuresome or tranquil as they choose. Ask them to share their stories with the rest of the class.

Take students on a field trip to the Milk River. Have them draw or paint the river. Send the pictures to another school in the watershed and ask them to send back pictures of the Milk where they live.

Have students read and discuss additional books with watershed themes such as *Paddle to the Sea* by Clancy H. Holling or *A River Ran Wild* by Lynne Cherry.

Resources

Cherry, Lynne. 1992. *A River Ran Wild.* San Diego, CA: Harcourt Brace and Co.

Holling, Clancy H. 1941. *Paddle to the Sea.* New York, NY: Houghton Mifflin Co.

Locker, Thomas. 1984. *Where the River Begins.* New York, NY: Puffin Books.

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Milk River Timeline

Grade Level:
Elementary, Middle School

Subject Areas:
History, Art, Social Studies

Duration:
Preparation Time: 30 Minutes

Activity Time: Up to two class periods

Setting:
Classroom

Skills:
Organize, Interpret, Evaluate, Apply, Present

Vocabulary:
migration, settlement, history, chronological order, timeline

Summary

Students construct a visual timeline to learn about the history of the Milk River region and its historical relationship to water.

Objectives

Students will:

- construct a timeline depicting major historical events that have affected the use and development of the Milk River Watershed.
- understand that the Milk River region has been collectively shaped by many people and events.
- describe the relationship between water resources and settlement in the Milk River Region.

Materials

- 15' of yarn
- Tape
- One copy of *Milk River Timeline Events* Student Copy Pages
- Scissors
- Paper, drawing materials
- Black line master of the Milk River Watershed (see centerfold of this book)

Background

It is often easy to think about time in the short term. But if one takes a longer view and reflects on the history of a place such as the Milk River region, it is often possible to better appreciate our lives and who we are in relation to those lives and events of the past. Constructing a visual timeline of the Milk River Basin and making connections with the past can help students better understand the present and help them make informed decisions in the future.

From its formation in the Ice Age to the present, the Milk River region has been shaped by a variety of events. Early influences include forces of nature and use by native people. The recent history of this region reflects influences from both Canada and the U.S. The influx of European immigrants and the changes brought by early explorers, trappers, miners, and homesteaders lead directly to the modern developments we know today.

History is a difficult and complex subject. To be useful and effective, the study of history must take into account many viewpoints and interpretations. For instance, consider how different the history of the Milk River region told by a Blackfeet elder might seem from one told by a great-grandson of a Hi-Line homesteader. With so many ways of interpreting history, students are well advised to approach historical information with both an open mind and an appreciation of different viewpoints and cultures. But, as any student of the Milk River region will soon realize, regardless of viewpoint, water has always been the most important influence on the region's history.

Photos courtesy Montana State University Special Collections.

Procedure

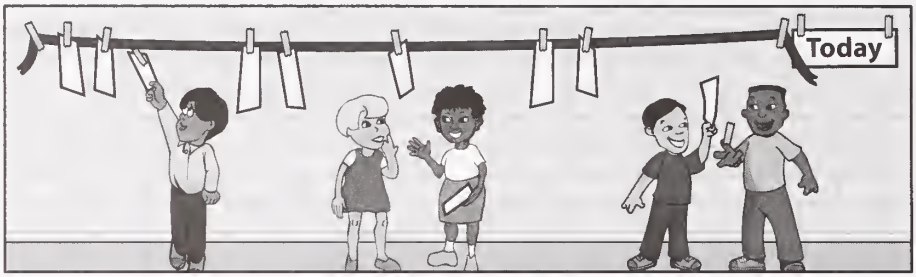
Warm Up

Ask students to brainstorm important historical events and processes that have shaped the Milk River region. What is the history of native people in the Milk River Watershed? When did Europeans first arrive? How did they make a living once they came? How did settlements grow and change?

The Activity

Part I

1. **Tape a piece of yarn along a wall in your classroom. This yarn represents a timeline. Mark the far right end of the yarn with a piece of paper marked "today."**
2. **Cut out the "timeline events" from the *Milk River Timeline Events Student Copy Pages* and shuffle them so they are not in order.** Give each student 1-3 events and instruct them to tape them along the yarn in chronological order. This may take a while and will inevitably involve discussion of what the distance should be between dates and what is considered the "beginning" of the timeline.
3. **Discuss the arrangement of events.** On the timeline, when did most events take place? What does this say about history? What does this say about how we record history? When does the timeline begin? What other events or processes can be added?
4. **Challenge students to draw a picture of an event of their choice. Discuss their pictures.** What did the area look like at the time of the event? What has changed since then? What is the same? How was water used at that time? How did the event change the Milk River region? Have students present their picture to the class and then display it next to the event on the timeline.



Part II

1. **Form the class into groups of three or four students. Each group will review the timeline and decide how water has influenced each of the historical events.** Was water important? If so, for what?
2. **Ask groups to discuss how historical events have affected settlement patterns in the Milk River Watershed.** How were settlement patterns affected by water? How has management of the Milk River changed the basin? What would the area look like if the Boundary Waters treaty had not been signed or if dams had not been built? The video *Milk River: Lifeline to the Hi-Line* makes the following statements: "without water, none of us would be here" and "without irrigation there would be no agriculture in the Milk River Basin." Given what they have discussed do students agree or disagree with these statements?
3. **Have groups share their findings with the class.**

Assessment

Have students:

- arrange a series of historical events in chronological order (Part 1 steps 2-4).
- describe a cause and effect relationship between a historical event in the Milk River and the present (Part 2 steps 1-3).
- describe the relationship between water resources and settlement in the Milk River region (Part 2 steps 1-3).

Extensions

Have students pick one event, or a series of events, from the timeline and write a play for the class to perform.

Have students interview an elder member of the community about what life was like in the Milk River region when they were young. How was their life different then? What has stayed the same? How has water affected their life through the years?

Resources

Malone, M. P., R. B. Roeder and W. L. Lang. 1991. *Montana: A History of Two Centuries.* Seattle, WA: University of Washington Press.

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Spritzer, D. 1999. *Roadside History of Montana.* Missoula, MT: Mountain Press Publishing.

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Milk River Timeline Events

Cut out events and hand out to students. Have them arrange events in chronological order on the timeline.

80-100 million years ago	Dinosaurs roamed the northern plains of North America, including what is now the Milk River Watershed.
~ 15,000 years ago	Glaciers begin to recede from their reach into what are now northern Montana and southern Alberta.
13,000 years ago	Early tribal peoples occupy what is now the Milk River Watershed, where they can hunt herds of large mammals.
8,000 years ago	Climate becomes increasingly dry. The northern prairie ecosystem begins to develop.
650	Blackfeet, Assiniboine, Gros Ventre, Cree, Crow, Kutenai, and Shoshone people use the Milk River Watershed.
1730	First horses arrive in Milk region. They are probably acquired at regional trading centers from tribes west of the Continental Divide.
1805	The Lewis and Clark Expedition reaches the Milk River on May 8, 1805. Lewis named the Milk River for its cloudy appearance. He wrote that the river had a "peculiar whiteness, being about the color of a cup of tea with the admixture of a tablespoonful of milk."
1830s	Devastating smallpox epidemics take the lives of 60-90% of Milk River Native Americans.
1847	Fort Benton trading post is named and assigned to protect the growing fur trade industry.
1862	The federal government passes the Homestead Act, which offers farms of 160 acres to people able to establish and maintain them.
1864	Montana becomes a territory.
1866	The cattle ranching industry begins when cows are brought from Texas to Montana. Cows graze on open range.
1877	October 5th, 1877. After fighting and traveling over 1700 miles from their home in Idaho, the Nez Perce surrender to General Miles a few miles south of what is today Havre, MT. Chief Joseph gives his famous speech, which concludes with "Hear me, my chiefs! I am tired. My heart is sick and sad. From where the sun now stands I will fight no more forever."
1880s	Montana territory experiences a boom in open range cattle. The first irrigation systems are constructed along the Milk River.

Milk River Timeline Events, continued

1883	Buffalo are effectively exterminated in Northern Montana.
1883-84	"Starvation Winter." Because buffalo are exterminated, many native people die of starvation. The loss of the buffalo also means the loss of their central figure of religious and community culture.
1886-87	Disaster strikes the cattle industry in the bitter winter of 1886-1887. Cattle die by the thousands in the howling blizzards and frigid temperatures. Ranching continues, but on a smaller scale.
1887	The first railroad across Montana's northern tier is built by James J. Hill's St. Paul, Minneapolis and Manitoba Railroad that would later became the Great Northern Railroad Company. Called the "Hi-Line," this railroad is instrumental in the development of towns and cities in the Milk River region.
1888	Fort Belknap Indian Reservation is established for the Gros Ventre and Assiniboine people on part of what remains of their ancestral lands. These once included all of central and eastern Montana and portions of western North Dakota. Today, the two tribes are united as one government called the Fort Belknap Indian Community.
1888	Fort Peck Reservation is established. The Fort Peck Reservation is home to two separate Indian nations, each composed of numerous bands and divisions. The Sioux divisions of Sisseton/Wahpetons, the Yantonais, and the Teton Hunkpapa, and the Assiniboine bands of Canoe Paddler and Red Bottom are all represented.
1889	Montana becomes the 41st state.
1889	First water right filed on the Milk River by T.B. Burns. With neighbors he constructs a community dam near present day Chinook.
1900	Montana's first homestead boom begins.
1904	The Bureau of Reclamation begins the Milk River Project, an effort that takes 40 years to complete. It furnishes water for irrigation of about 121,000 acres in the Milk River Watershed.
1907	Harsh winter takes substantial toll on cattle operations. However, the industry sustains fewer losses than in 1876-77 due to improved ranching methods.
1909	United Kingdom and the United States sign the Boundary Waters Treaty, agreeing to divert part of the St. Mary's River to the Milk River for irrigation.
1910	Glacier National Park is established by an act of Congress. The park covers 1,600 square miles and contains headwater streams of the Milk River.
1910	Record forest fires burn 100,000 acres in Glacier National Park.

Milk River Timeline Events, continued

1916	Rocky Boy's Reservation, the last reservation created in Montana, is established for Chippewa and Cree tribes.
1917	The US enters World War I.
1919	World War I ends, but drought and post-war depression cause great hardship in the Milk River region.
1921	Lake Sherburne Dam is completed.
1930s	The "Dust Bowl" years. This decade of crippling drought hits Milk River region hard. Many homesteaders abandon their farms and move away.
1933	To combat ongoing depression and drought, President Roosevelt begins the New Deal program. Considerable resources are directed to Montana farmers, ranchers, and forest projects. The largest single investment goes to building the Fort Peck Dam. Construction is completed in 1940.
1939	Fresno Dam near Havre is completed.
1941	United States enters World War II.
1951	Frenchman Creek storage dam north of Saco completed.
1952	Floodwaters raise the Milk River to historically high levels. Thousands of people lose their homes and much of the cattle industry is wiped out.
1957	Writing-On-Stone Provincial Park is established in Alberta.
1965	Flood destroys the Paradise Valley Diversion Dam.
1966	The rebuilt Paradise Valley Diversion Dam is completed.
1988	Severe drought and numerous fires affect much of Montana and southern Alberta, including the Milk River region.
1989	Montana celebrates 100 years of statehood.
1991	An October storm ignites a rangeland fire that burns 184,000 acres in Blaine County between Havre and Chinook.
2000	Drought and a massive fire season affect Montana and southern Alberta.
2001	Continuing drought draws down reservoirs to extremely low levels. Some counties in the Milk River Basin receive less rainfall than during the dust bowl era.

Pass the Jug

Grade Level:
Middle School

Subject Areas:
Social Studies, Environmental Science, History, Government

Duration:
Preparation Time:
Part I: 15 minutes
Part II: 15 minutes

Activity Time:
Part I: 30 minutes
Part II: 30 minutes

Setting:
Classroom

Skills:
Organize, Analyze, Apply

Vocabulary:
riparian areas, water rights, water allocation, consumptive use, nonconsumptive use, snowpack, streamflow

Summary

Students simulate and analyze different water rights policies to learn how water availability and people's proximity to the resource influence how water is allocated.

Objectives

Students will:

- describe historical and current aspects of water rights.
- illustrate how water rights are used to allocate water.
- evaluate water rights allocation systems.

Materials

- Large quantity of candy, popcorn, pencils, stickers, or other items appropriate for distribution
- One copy of *Water Rights Q & A* Student Copy Pages for each student
- Paper cups or glasses (one per student plus extras)
- Water jug (e.g., apple cider or gallon milk container)
- *Water Users (Descriptions)* Student Copy Page (cut into strips)
- Funnel

Background

Water rights provide an organized and systematic manner for allocating water. A water right allows a person, business, community, or other group to use a specified amount of water. People receive only the right to use the water; they do not own the water.

The history of water rights is related closely to settlement and land ownership. Settlers in the East adapted to water rights policy similar to what the populace used in England. The Riparian Rights or Common-Law Doctrine gives people who own land bordering a water source the right to use that water however they choose. A more recent version of the doctrine requires people to justify their uses as reasonable. They must also ensure that landowners downstream have their fair share of the water.

East of the Mississippi, average annual rainfall is more plentiful than the West. This is apparent from a geographical view. From about the 98th meridian of longitude west of the Pacific coast, average annual rainfall dips significantly below the 20 inches that normally sustain nonirrigated crops in the East.

Scarcity generates Westerners' preoccupation with water and water rights. Western water rights were developed for the needs of 19th century settlers. They evolved from the customs and practices of miners from about 1848, who developed systems for protecting their claims to land and minerals. More than one hundred years later, after investing billions of dollars to build water diversion and storage projects such as ditches, dams, and reservoirs, westerners remain strongly committed to ensuring a continued supply of water for their irrigation and mining needs.

In many parts of the West, the Prior Appropriation Doctrine regulates water rights. This doctrine maintains "first come, first served," or first in time is first in right." In other words, whoever uses the water first has the "prior" or first right to the supply of available water. If all the water in a stream is allocated, no new users are allowed.

Exceptions to the state-based Prior Appropriation Doctrine are federal and tribal reserved water rights. Reserved water rights were created to provide adequate water for lands owned by the federal government and Native American nations. Unlike state rights allocated under the Prior Appropriation Doctrine, reserved rights on

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federal and tribal lands do not have to be used to be valid.

In the last 20 years, many changes have added new dimensions to water rights and water allocation programs. Irrigated agriculture is a large consumer of water. Individuals and corporations invest millions of dollars in irrigation systems to grow crops for people and for livestock. Cities also need water to meet the needs of residents, businesses, and industries. Water for recreation and for fish and wildlife is receiving growing attention. Many communities depend on water resources for energy production methods such as hydroelectric and thermoelectric generation plants. The challenge of meeting today's growing demand for water will involve nontraditional allocation strategies. Several methods, such as water rights transfers, water rights changes, water marketing, and water leasing, have evolved as considerations to satisfy twentieth-century needs.

Procedure

Warm Up

Present students with a large quantity of candy, popcorn, pencils, stickers, or whatever is appropriate for distribution. Ask them how you should distribute the items to the students in the class. Should you give everyone an equal amount? Should you give a larger quantity to the first person who asks or to the student who arrived first at school that day?

After students discuss various methods for sharing the candy or stickers, tell them that you are going to be discussing how people in the East and West share water. Distribute one copy of Water Rights Q & A Student Copy Pages to each student. Use these questions and answers to guide your initial discussion of water rights with students.

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The Activity

Part I

1. Arrange students' seats in a row or around a table and give each student a cup. Starting at one end, have the first student pour out as much water from the water jug as he or she needs and pass the jug to the next student in line. Because of the limited amount of water in the jug, there might not be enough to go around.
2. Ask students (those who received water and those who did not) to express how they feel. Tell them that sometimes there is not enough water available to meet everyone's needs.
3. Ask students what they could do to make sure they all get water. Have them repeat the activity and put their plan into action.
4. Provide students with a brief description of riparian rights. Ask them to explain how passing the jug relates to riparian rights.

Part II

1. After students have emptied their cups, inform them they will now simulate the allocation of water rights in many places in the West. Explain how the Prior Appropriation Doctrine gives people who originally moved into an area and started using water the right to use water first, whether or not their land borders the water source.
2. Have each student write down his or her birth month and day on a piece of paper and display it so everyone can see. Then distribute Water Users (Descriptions) Student Copy Page by handing the strips out in the order of students' birthdays (from January 1 to December 31). This process represents the concept of first in time, first in right.
3. Explain that the descriptions are numbered. The student with description number one is the first person who moved into the area ("first in time"). Along with the right to use the water, each description also states how the water is used and how much is needed. NOTE: An alternative is for students to make up their own use and water quantities needed.
4. Pass around the jug of water in the order of numbered cards. Have students read aloud how they use water. Each student must take the amount of water indicated on his or her card. Some water users, such as fisheries and hydroelectric power plants, utilize water without reducing water quantity; water managers call these users nonconsumptive. (However, reservoirs associated with

hydroelectric power plants do lose some water to evaporation.) Students who represent these water users should pour water into their cups and then funnel it back into the jug.

5. When water runs out, have students express their opinions about this system. What are the benefits of this system? (It protects the investments [money, time, and energy] and the rights of first water users.) What are some shortcomings? (It restricts new or different water users' access to water.) How or why would students change the system?

Wrap Up

Have students summarize the two general approaches to allocating water rights and how each evolved. Encourage students to investigate options for individuals or groups of people who do not have enough water. For example, they could promote conservation, invest in engineering projects that collect or divert water supplies, etc.

Have students research water allocation in their community. (They should contact a city or state water works manager or the public health department.) Suggest that they create a display for the second school outlining their community's and/or state's water rights system (e.g., "Our Water Rights Made Simple").

Assessment

Have students:

- develop a strategy to distribute a limited resource (e.g., a bag of candy, an hour of television time, a five dollar bill) among students in the class (*Warm Up* and Part I, step 3).
- compare and evaluate different approaches to allocating water rights (Part II, steps 5 and *Wrap Up*).
- summarize how water rights practices evolved (*Wrap Up*).

Extensions

To simulate annual fluctuations in streamflow, change the amount of water in the jug. Some years have heavy streamflow; in other years the river runs dry. Simulate a drought by asking students not to drink water one hour prior to the activity. You might even take a short hike to generate thirst.

To demonstrate how pollution affects water users, have students add a drop of food coloring or dunk a tea bag in their cups—simulating their "use" of the water. Students will return some of this used water to the jug (demonstrating runoff and discharge). Add a sugar lump to symbolize invisible chemicals that are carried in water. Have students list how water quality can affect water quantity.

To simulate snowpack, freeze colored water in layers in a plastic liter bottle. The layers represent the amount of water that is frozen or "held" in snowpack over the winter. The first layer, colored green, represents November, the second, colored red, symbolizes December, and so on through the top clear layer, March. (The colored layers will remain distinct as long as each freezes solid before the next layer is added. The four colors in a box of food coloring plus one clear layer will make up the five layers [or months] necessary.)

Arrange students in a circle and distribute cups and tell them that you will "pass the jug" once again. Hand the first student the frozen bottle of water and suggest that he or she pour into the cup whatever is needed. When students express confusion, ask them what must happen before they can share this water. Inform them that in some parts of the country snow accumulations in the mountains through the winter months (November through March) and results in "snowpack."

In spring, warmer temperatures melt this snow and the water is released. Streams are often swollen (sometimes overflowing their banks) during the spring thaw. This water is critical for irrigating crops, for providing lush vegetation for grazing wildlife and livestock, and for filling reservoirs that may have been drawn down over the winter months.

Remind students that snowpack is often referred to as a "water bank." That is, water is "saved" until the rise in temperature (above 32 degrees F [0 degrees C]) "opens the bank." Ask students to speculate on what conditions might exist in the spring if there was very little precipitation during the winter and a reduced snowpack.

Have students adapt "Pass the Jug" to demonstrate how federal reserved water rights could affect water allocation. These rights are designed to ensure that public lands (e.g., parks) and Native Americans receive the water they need. Their demands can sometimes supersede other water rights systems (e.g., riparian, prior appropriation).

Demonstrate needs of in-streamflows for fish and wildlife by placing a fish bowl at the end of the line of students. Explain that at least one cup of water must be poured into the fish bowl to meet this requirement. How do your students adjust to meet this new need?

Resources

Getches, David. 1990. *Water Rights in a Nutshell.* St. Paul, MN: West Publishing Co.

Marstib, Betsy. 1987. *Western Water Made Simple.* Washington, D.C: Island Press.

The Milk River International Alliance. 2003. "Water Rights." In *The Milk River Alliance: International Lifeline of the Hi-Line, A Guidebook.* Havre, MT: The Milk River International Alliance. 12-14.

Wolfe, Mary Ellen. 1994. A *Landowner's Guide to Western Water Rights.* Bozeman, MT: The Watercourse.

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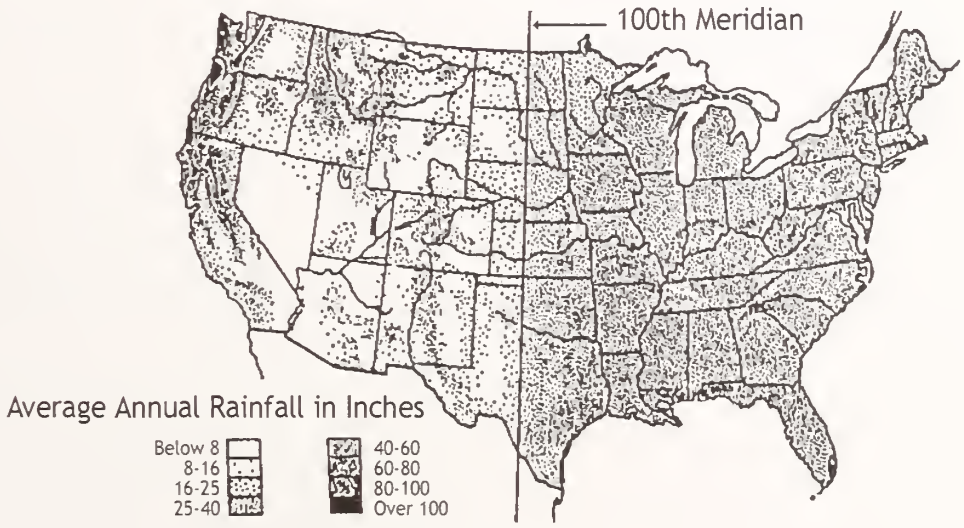
Water Rights Q & A

Questions	Answers
1. Study the 100th meridian map below. How much rain falls east of the 100th meridian as compared to west of it? Would the scarcity of water in the West have anything to do with the fact that people in the West are very concerned about water and their right to use water?	1. East of the Mississippi, average annual rainfall is more plentiful than in the West. From about the 100th meridian of longitude west to the Pacific Coast, average annual rainfall dips significantly below the 20 inches that is normally needed to sustain crops that are not irrigated in the East.
2. What is a water right?	2. A water right is a right to use a public resource for a beneficial or useful purpose. Water rights are considered property rights, but people do not actually own the water; they own the right or privilege to use the water.
3. Who needs a water right?	3. Anyone who is diverting water (capturing water before it is put to some other use) or controlling water in a western state needs or should already have a water right. Farmers or ranchers who irrigate crops may hold water rights; people who supply water to cities or towns may hold water rights; industries that need water to manufacture their products may hold a water right.



Water Rights Q & A, continued

Questions	Answers
4. Does my family need a water right if we live in a western city and get our water from the city?	4. No, the water right is usually held by the agency that supplies the water to the city.
5. What is a consumptive use of water?	5. Consumptive water use means that some part of the water diverted is consumed, making at least a portion unavailable for use by others. Irrigation, private domestic wells, fish raceways and ponds, and stock water ponds (where cattle, sheep, etc. get their water) are all examples of diversionary, consumptive uses of water.
6. What is an instream (nonconsumptive) use of water?	6. Instream water may include water for hydropower production, fisheries and wildlife habitat, water quality protection, and stream channel protection. Some states have adopted laws and regulations that provide protection for these nonconsumptive uses. In effect, these laws "speak for the fish!"
7. What is the prior appropriation system?	7. The prior appropriation system is a widely used method to distribute water in the West for many uses and needs. It rests on the idea of "priority," sometimes referred to as, "first in time, first in right." What does that mean? Whoever began using water first (the senior user) has the right of first use. Also, the senior user is entitled to his full amount of water before those who received a later water right (the junior users) get their share.

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Water Rights Q & A, continued

Questions	Answers
8. Are there any other kinds of water rights besides the prior appropriation system?	8. There are federal and tribal reserved water rights. Reserved water rights were established to provide water for lands owned by the federal government and Native American nations. Water rights evolved with settlement partners and land ownership. People who first settled in the eastern United States, where precipitation can be abundant, adopted a water rights policy that was similar to what they had known in England. The Riparian Rights or Common-Law Doctrine gives people who own land bordering a water source the right to make reasonable use of the water on that land if the use does not interfere with the reasonable uses of other riparian landowners.
9. Can a person lose a water right?	9. Yes, water rights under the prior appropriation system can be lost if they are not used, often within particular time periods. In some states, new laws are being considered that would allow the owner of a water right to sell his excess water. This may help to prevent water waste.
10. So, is this all there is to know about water rights?	10. No! Although this is a good introduction, water rights are very complicated and the laws are different from state to state and change over time. If you or your parents would like to learn more about western water rights, you can read the book from which this material was adapted: *A Landowner's Guide to Western Water Rights* by Mary Ellen Wolfe, produced by The Watercourse and published by Roberts Rinehart Publishers, 1996. Copies are available by calling The Watercourse at (406) 994-5392.

Water Users (Descriptions)

Number 1	You are a descendant of the first homesteader that moved into the area. You own a goat dairy farm and grow alfalfa and corn.	use 2 cups
Number 2	Your ancestor was heading toward California during the great gold rush, but got distracted by flowers. While picking daisies, he found a huge deposit of copper and started a copper mining company. Your family runs this small, but lucrative, operation.	use 2 cups
Number 3	Your great-great-grandmother came out to teach the children of the copper miners. You still live on the property she bought and need water for personal use and crop irrigation.	use 1 cup
Number 4	You represent a small community of families who work in the mine. You use water for daily domestic and irrigation purposes. Your water needs may increase as the town grows.	use 2 cups
Number 5	Your grandparents left their farm in Iowa to start a farm here. You help meet the needs of the growing community. Your grandfather is still alive and resists using modern farming practices.	use 5 cups
Number 6	To avoid the competition in the big city, your father moved his coat hanger factory to this growing community. The industry provides a means of income for community members.	use 2 cups
Number 7	You represent a hydroelectric company with a dam upstream of the town. The water you use passes through the dam to generate electricity. Show this by pouring three cups of water back into the jug.	use 4 cups
Number 8	You represent a town that grew as more people escaping the city moved to the countryside. Consequently, your town has become a city. You use water for domestic and irrigation purposes.	use 3 cups
Number 9	You are a high-tech farmer that has moved here to supply food to the growing communities.	use 2 cups
Number 10	You have decided to start an industry that you think meets a growing need: shoulder pad storage racks.	use 1 cup

The rest of the user cards can be copied and numbered in any order. If the community is allocated only one jug of water, there will probably be no water left by this time.

	Small farmer	1 cup
	Industry	1 cup
	Small town	1 cup
	Rancher	1 cup

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Buckets of Money

Grade Level:
Middle School, High School

Subject Areas:
Language Arts, Math, Life Science, Earth Science, Ecology, Economics

Duration:
Preparation Time: Up to 100 minutes to gather and prepare materials

Activity Time: Up to two class periods

Setting:
This is an outdoor activity. A schoolyard or other outdoor area with access to a hose or water source is required. A warm sunny day is ideal.

Skills:
Gather, Analyze, Evaluate, Apply, Present

Vocabulary:
irrigation, conservation, treaty, costs, irrigation efficiency, balance, cooperation

Summary

Students become irrigators and learn the balance of factors that make up irrigation efficiency.

Objectives

Students will:

- define irrigation efficiency.
- explain the costs and benefits of different irrigation systems.
- present a fair policy for water distribution to all water users.
- explain what factors of irrigation efficiency are within the control of irrigators and which are not.

Materials

- One 50-gallon trash can (clean)
- Five 5-gallon buckets
- Five 1-gallon buckets (gallon ice cream buckets are perfect)
- Drill and 1/4-inch drill bit
- $100 in play money for each station —please see enclosed copy page
- Access to a hose or water source

Please Note: Students will likely need a change of clothes.

Background

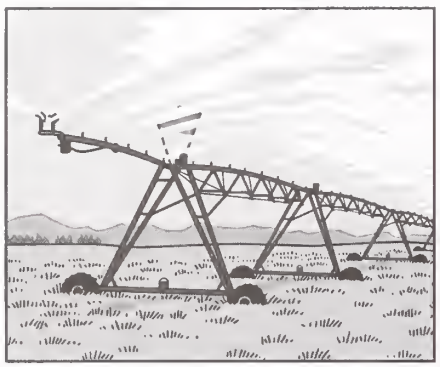
Agriculture uses the most water in the Milk River Basin. The process of acquiring water, delivering it to where it is needed, and applying it to crops at the correct time and in the correct quantity is called irrigation. Irrigating effectively involves careful decisions about money and energy costs. By participating in this hands-on activity, students will understand the relationships between efficiency, cost, and energy use in irrigation as they try to develop the most efficient system possible.

Irrigation efficiency is essentially the efficiency associated with acquiring water, delivering it to fields and applying it to crops. Efficiency is determined through a combination of factors including how much water is lost between the point of diversion and the point of use (mostly through evaporation and leaky ditches and pipes), the cost of delivering the water (mostly through equipment, energy, labor and other infrastructure costs), and how well the soil holds water once water is applied (for example, clay soils tend to hold water near the surface where plants can reach it longer than sandy soils which drain quickly). Given this, it is imperative to note that no two farms, and no two irrigation systems, are exactly alike. Differences in soil, landform, distance to water, cost of energy, and other factors make each situation unique, with its own challenges and benefits. Even the most modern irrigation technology combined with outstanding soils can't provide 100% efficiency. If such a system did exist, it would probably be so cost prohibitive that no one could afford it. In the Milk River Watershed, water is a scarce commodity that cannot be wasted, and everyone must do their best to get the most out of each gallon. Conservation and cooperation are key to ensuring that everyone in the Milk River Basin gets the water they need.

The following are some of the most common methods of irrigation in the Milk River region.

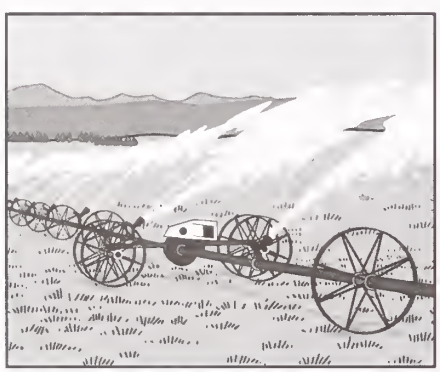
Center-Pivot Irrigation - A center-pivot irrigation system is an electric powered automated sprinkler that delivers water via a wheeled rotating boom with a center pivot point. Water is applied uniformly by a progressive increase in nozzle size from the pivot to the end of the line. The rate at which water is applied is determined by how

fast the pivot travels. Most units are about 1,250 feet long and irrigate about 130 acres.



Center-pivot irrigation.

Wheel-Line Sprinkler - In a wheel-line sprinkler system water is delivered to crops via sprinkler heads mounted on a pipe which is elevated on moving wheels. Water pressure, generated with electric pumps, propels the system.

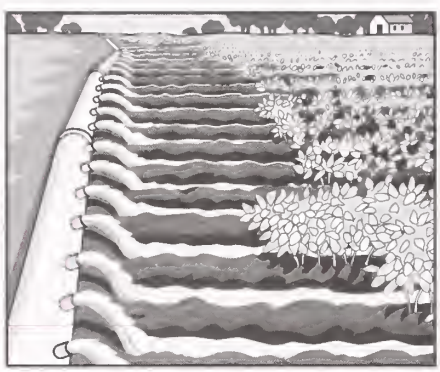


Wheel-line sprinkler.

Hand-Line Sprinkler - In a hand-line system sprinkler heads, mounted at intervals along a long pipe laid on the ground across a field, deliver water to crops. The name of this system is derived from the fact that the irrigation pipe must be moved by hand regularly in order to irrigate a field evenly.

Hand-line sprinkler.

Flood Irrigation - Flood irrigation is a process in which the entire surface of the soil is covered (flooded) by water. Water is typically delivered via an irrigation canal or pumped to fields using electric or gas powered pumps. Fields are typically flooded at intervals through the growing season.



Flood irrigation.

Procedure

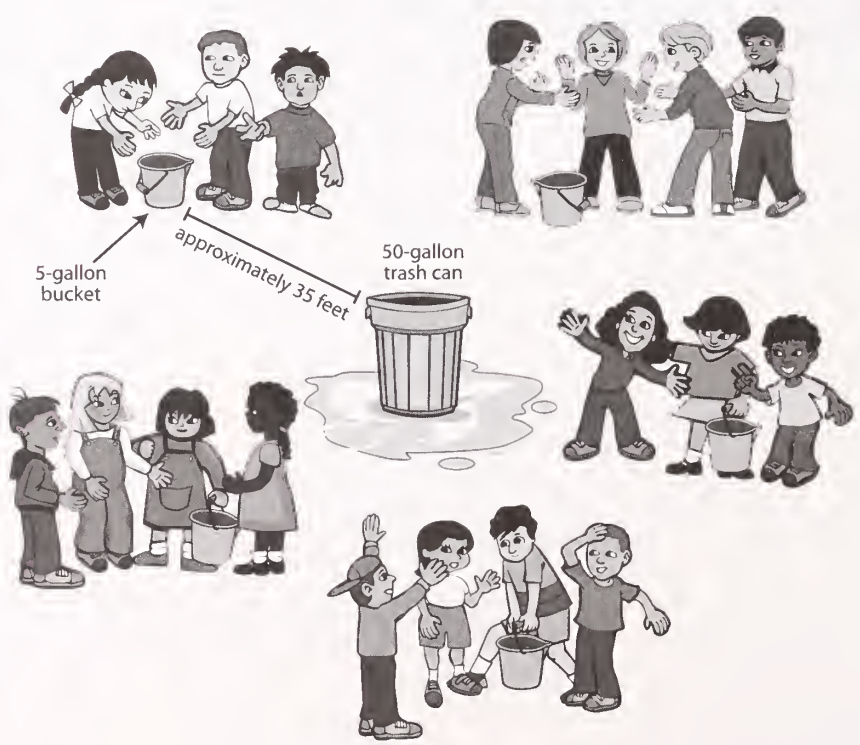
Warm Up

Ask students to describe the different types of irrigation systems they know about or that they have seen in their area. If students are farmers or ranchers, have them describe why their family uses the irrigation system that they do. Discuss the concept of irrigation efficiency. Do students have opinions about which irrigation systems are the most efficient? Why do they feel that way? Why would irrigation efficiency be important in the Milk River Watershed?

The Activity

1. **Prior to starting this activity, drill the following number of 1/4 inch holes in the bottom of the 1-gallon buckets:**

- Bucket #1 – 5 holes
- Bucket #2 – 10 holes
- Bucket #3 – 20 holes
- Bucket #4 – 30 holes
- Bucket #5 – 35 holes



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When you are finished, stack the buckets and do not let your students see the holes in them.

2. **Set up the outdoor playing field in the following way: Fill the 50-gallon trash can (representing the river) with water. Arrange the 5-gallon buckets (representing the fields) in a circle with the trash can in the center. The buckets should be about 35 feet from the trash can.**
3. **Divide students into five groups and pass out $100 in play money to each group. Then read the following instructions:**

- Each group represents a family farm in the Milk River Basin.
- They have in their possession $100 to get them through the irrigation season.
- The goal of this activity is to irrigate their crops for the season (represented by filling a 5-gallon bucket to the top) using an irrigation system (a 1-gallon bucket). The "winner" is the family who has the most money left after purchasing an irrigating system and paying the costs to irrigate for a season.

4. **With this in mind, tell the "families" to make a plan to purchase an irrigation system. How much do they want to spend? With a bit of a flourish, (but without showing students the bottom of the buckets) proceed to "sell" (the 1-gallon buckets) the "irrigation systems" for the prices listed in the table below.**

Naturally, students will have different levels of satisfaction with the buckets they receive. Discuss how some irrigation systems are more efficient than others are and that efficiency is often a reflection of cost.

5. **Next, inform the students of the rules of the game.**

- Teams fill their buckets from the 50-gallon trash can at the same time— making trips until they fill their 5-gallon buckets or run out of money.
- Each trip to the "river" costs $5 for energy and labor, which they will pay to you when they are finished irrigating. It is the responsibility of each "family" to keep track of how many trips they take to fill their bucket and to pay you when they are finished.
- The 5-gallon bucket must stay in the same place (aka play fair).

6. **Have students take their places at their white 5-gallon buckets.**

Before they begin, have students calculate the number of trips they can afford to make to the trash can after purchasing their irrigation system. Have them predict whether they will have enough money to fill their 5-gallon bucket.

7. **When students are ready to begin, shout "Irrigate!"**

The "families" begin to fill their 5-gallon buckets, some with more success than others. "Families" should haul water (irrigate) until they either fill their buckets or run out of money. WARNING – Depending on the enthusiasm of students, everyone, including you, could end up very wet!

8. **At the end of the activity, there should be a mixture of results. One or two "families" will be soaking wet and gasping for breath. Other "families" will have varying levels of money and energy remaining.**

- Have each "family" tally its irrigation costs and pay their expenses. Have each briefly describe the pros and cons of their particular irrigation system with the entire group gathered around their "field."
- Who "won" the activity? Why?
- What factors caused success or failure?
- Discuss how each bucket represents a different type of irrigation system, each with differing *levels of efficiency.*
- Ask students if they can define irrigation efficiency (they should have no problem, once they have caught their breath!).
- Ask students to think about what might make for a more efficient irrigation system. Why don't all farmers use the most efficient system?

9. **Repeat the activity using the following scenarios. If there is not enough time to perform the scenarios take the time to discuss them.**

Scenario 1: Energy costs skyrocket— each trip to the river now costs $15!

- How does this change each group's irrigation efficiency?
- Which irrigation system is the most attractive now?
- Discuss the "costs" of technology.

1-Gallon Bucket	Number of Holes	Cost	Represents
Bucket #1	5 holes	$70	State of the art electric-powered center pivot irrigation system
Bucket #2	10 holes	$60	New wheel-line sprinkler irrigation system
Bucket #3	20 holes	$50	Used wheel-line system (a bit worn)
Bucket #4	30 holes	$30	Hand-line sprinkler irrigation system
Bucket #5	35 holes	$10	"Old fashioned" hand dug flood-irrigation

Scenario 2: **Drought year! Fill the 50-gallon trash can only halfway to represent a drought.**

- Are those leaky irrigation systems fair to other water users when water is in such short supply?
- Why should some irrigators pay for more efficient irrigation systems when others "waste" water using inefficient systems?

Scenario 3: **Students pay a flat rate for water – but are still affected by the efficiency of upstream irrigators.**

a. Fill the trash can three-quarters full. Form the students into the same groups and give each group $100 of play money. Arrange the buckets in a line leading away from the 50-gallon can, placing the least efficient bucket (one with the largest number of holes in the bottom) closest to the trash can. Place the remaining buckets in order of increasing efficiency with the most efficient bucket (one with the least number of holes) farthest away. (IMPORTANT! Do not let students know this is how you have set up the buckets.)

b. Conduct an auction where farmers bid on the various buckets. Inform students, after the bidding is done, that they will pay $20 up front for unlimited water, NOT for each bucket. If they had received this information earlier, would it have affected their choice of buckets?

c. Allow students to irrigate one group at a time beginning with the team closest to the 50-gallon trash can. Tell students that this represents the farmer who lives farthest upstream and does not need to worry as much about the efficiency of his or her irrigation system. That "farmer" should continue filling his or her bucket until he or she has reached the top. Continue until all teams have a chance to fill their buckets, or until the water is completely gone.

d. The last "farmer" will not have enough water to fill his or her bucket, despite having the most efficient irrigation system. This simulates real-life; farmers living farther away from a water source often need the most efficient method of irrigation, yet may receive the least amount of water.

e. Discuss the importance of communication and cooperation between various users. This is why watershed groups and water-user associations are formed.

Wrap Up

Assign one student or an adult to be an objective listener. Have students discuss what happened in each scenario. Then have each team make a presentation to the listener on how to fairly distribute water. Remind students that though they want to be fair to their neighbors, they must make sure that they get enough water themselves. The listener must then decide on an equitable way to distribute water to all users. Have the class come up with changes to the activity that would minimize waste and allow everyone to get the water they need.

Assessment

Have students:

- define irrigation efficiency *(Warm Up).*
- explain the costs and benefits of different irrigation systems *(Warm Up).*
- explain what factors of irrigation efficiency are within the control of irrigators and which are not (steps 8-9).
- present a fair policy for water distribution to all water users *(Wrap Up).*

Extensions

Using what they have learned in this activity have students write up a "treaty" amongst themselves, stating how water will be distributed. All members of all teams must agree to the treaty. This will be a difficult task for the class, but it simulates what happens with farmers and ranchers in real life. Frame the final treaty and place it on the classroom wall.

Have students write an essay describing what type of irrigation system they would use if they were a farmer or rancher. Be sure they clearly state why they would choose the system they prefer. What factors were not addressed in this activity?

Resources

Conserve Water Educators Guide. 2000. Bozeman, MT: The Watercourse.

The Milk River International Alliance. 2003. "Water Conservation." In *The Milk River Alliance: International Lifeline of the Hi-Line, A Guidebook.* Havre, MT: The Milk River International Alliance. 32-33.

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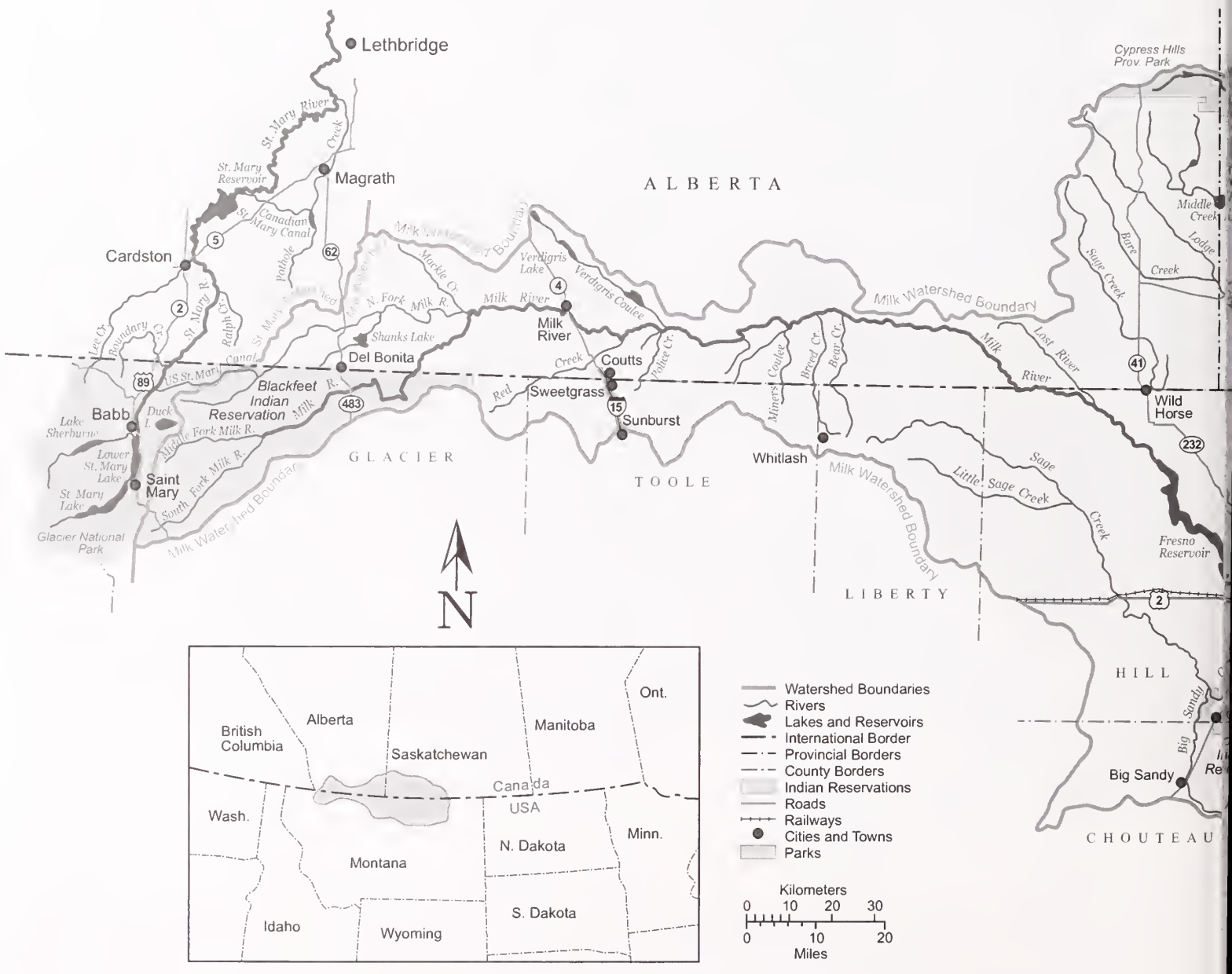
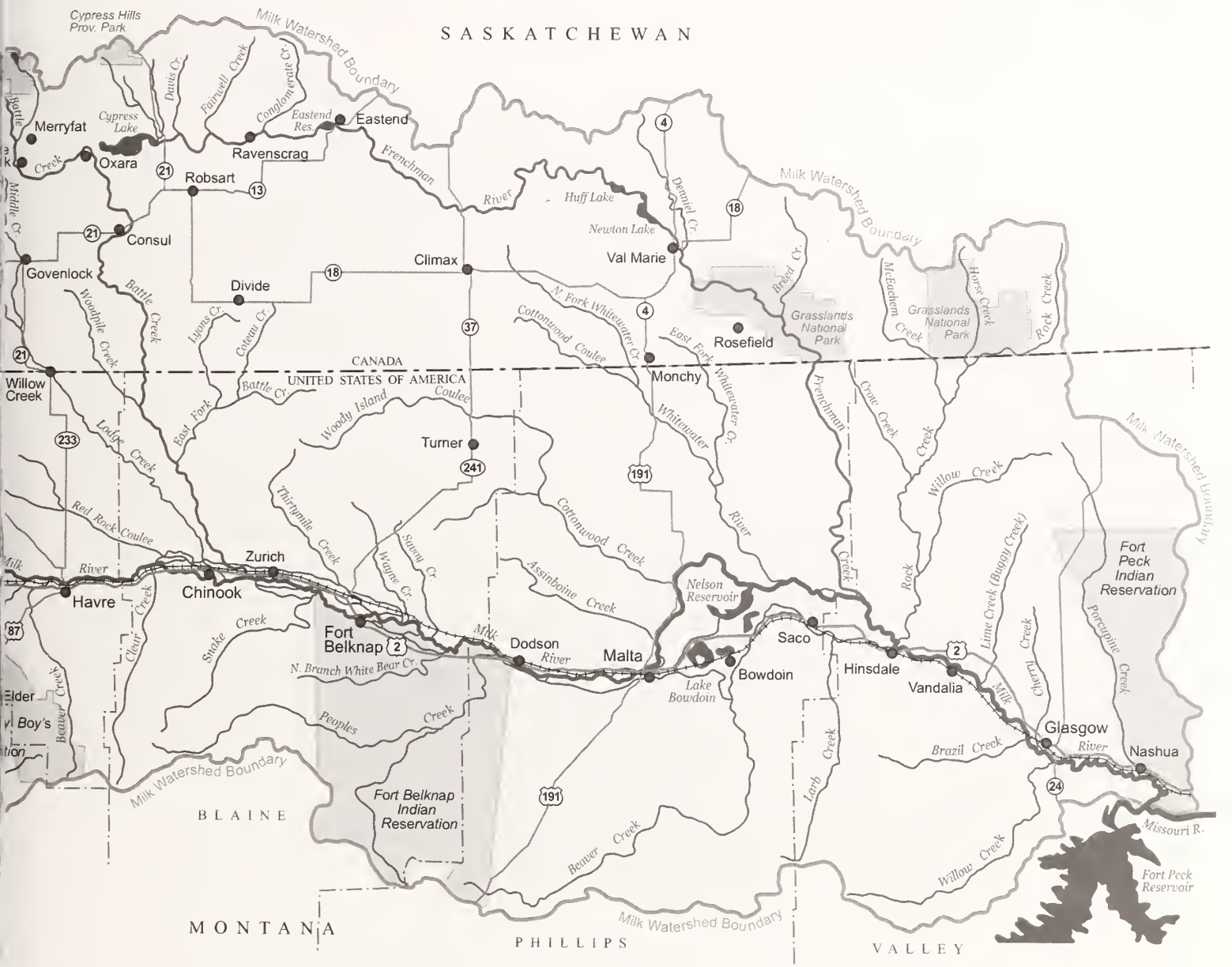
Milk River


Lethbridge
St. Mary River
St. Mary Reservoir
Magrath
ALBERTA
Cypress Hills Prov. Park
Middle Creek
Lodge Creek
Sage Creek
Bare Creek
Canadian St. Mary Canal
Cardston
Pothole
Milk Watershed Boundary
Verdigris Lake
Verdigris Coulee
Milk River
Milk River
Milk Watershed Boundary
Lee Cr.
Boundary Cr.
St. Mary R.
Ralph Cr.
N. Fork Milk R.
Mackie Cr.
Shanks Lake
Del Bonita
Coutts
Police Cr.
Red Creek
Sweetgrass
Miners Coulee
Breed Cr.
Bear Cr.
Milk River
Lost River
Wild Horse
Babb
Lake Sherburne
Duck L.
Blackfeet Indian Reservation
Middle Fork Milk R.
Lower St. Mary Lake
Saint Mary
St. Mary Lake
South Fork Milk R.
Glacier National Park
Milk Watershed Boundary
GLACIER
TOOLE
Sunburst
Whitlash
Milk Watershed Boundary
Little Sage Creek
Sage Creek
Fresno Reservoir
LIBERTY
HILL
Big Sandy
Big Sandy
CHOUTEAU
N
Ont.
British Columbia
Alberta
Saskatchewan
Manitoba
Canada
USA
Wash.
Montana
N. Dakota
Minn.
Idaho
Wyoming
S. Dakota
Watershed Boundaries
Rivers
Lakes and Reservoirs
International Border
Provincial Borders
County Borders
Indian Reservations
Roads
Railways
Cities and Towns
Parks
Kilometers
0 10 20 30
0 10 20
Miles

Watershed


SASKATCHEWAN
Cypress Hills Prov. Park
Milk Watershed Boundary
Merryfat
Cypress Lake
Oxara
Ravenscrag
Eastend Res.
Eastend
Frenchman River
Robsart
Consul
Govenlock
Divide
Climax
Huff Lake
Newton Lake
Val Marie
Rosefield
Grasslands National Park
CANADA
UNITED STATES OF AMERICA
Willow Creek
Monchy
Turner
Woody Island Coulee
Cottonwood Coulee
Zurich
Chinook
Havre
Fort Belknap
Dodson
Malta
Nelson Reservoir
Lake Bowdoin
Bowdoin
Saco
Hinsdale
Vandalia
Glasgow
Nashua
Missouri R.
Fort Peck Reservoir
Fort Peck Indian Reservation
Fort Belknap Indian Reservation
Milk River
Cottonwood Creek
Assiniboine Creek
Willow Creek
Beaver Creek
Peoples Creek
Brazil Creek
Lamb Creek
Porcupine Creek
Cherry Creek
Lime Creek (Buggy Creek)
BLAINE
MONTANA
PHILLIPS
VALLEY

Water Audit

Grade Level:
Middle School

Subject Areas:
Math, Health, Environmental Science

Duration:
Preparation Time: 10 minutes

Activity Time: two 50-minute periods

Setting:
Classroom and Home

Skills:
Gather, Organize, Analyze, Interpret, Evaluate

Vocabulary:
audit, desalinization, water, diversion, retrofitting, potable

Summary

Students conduct a home water audit and compare and contrast results with and without the implementation of water conservation practices.

Objectives

Students will:

- provide a rationale for implementing home water conservation measures.
- describe the benefits of at least five home water conservation practices.
- recommend water conservation strategies to be implemented within their own homes.

Materials

- *Conserve Water!* Student Copy Page
- *Water Audit Data Sheet I* Student Copy Page (one copy per student)
- *Water Audit Data Sheet II* Student Copy Page (one copy per student)

Background

Earth is often referred to as the blue planet or the water planet. Photographs of Earth taken from space are predominantly colored in shades of blue. This is not surprising since water circulating in oceans or frozen in ice fields covers about 71 percent of the planet. In fact, scientists estimate that there is enough water on Earth to cover the whole United States with water 93 miles deep! Nature uses and moves more water through the water cycle than any other system. For example, each day the sun evaporates 1,000,000,000,000 (one trillion) tons of water.

Switching from the global to the personal perspective, the human body has nearly the same percentage of water as the planet—about 65-70 percent. The brain is almost all water (95 percent) and sayings that allude to "dry bones" are misleading—the human skeleton is 25 percent water.

So, if we are such watery creatures living in a watery world, why do we need to use water wisely? It boils down to a simple formula: the right amount of water, in the right place, of the right quality, at the best price. Water that is good enough to drink, that can be used by agriculture or industry and shared with wildlife, is a precious resource.

All of the water on the planet is not available for use by plants or animals. About 97 percent of the water on Earth is found in oceans. Only about 3 percent is fresh. Of this fresh water, a large percentage is frozen in icecaps and glaciers or is unavailable because it is too far underground, polluted, or trapped in soil. Stated simply, if a bathtub holding 30 gallons represented all the water in the world, about one-half teaspoon of water would symbolize the amount of potable, available fresh water.

On a global scale, only a small percentage of water is available, but this percentage represents a large amount per individual. The irony is that for some people water may appear plentiful while for others it is a scarce commodity. Water is not equally distributed on the planet, and its availability depends on geography, climate, and weather.

For example, in the Western United States, the climate is predominantly dry. In many areas, people rely on systems of dams and diversions to deliver fresh water, often from distant places. The water that runs from a tap in Los Angeles, California, has likely traveled hundreds of miles from the Rocky Mountains down the Colorado River and across the Mojave Desert. This delivery system is not only extensive, it is expensive!

Even if you live in a water-rich area, water treatment costs money. Water

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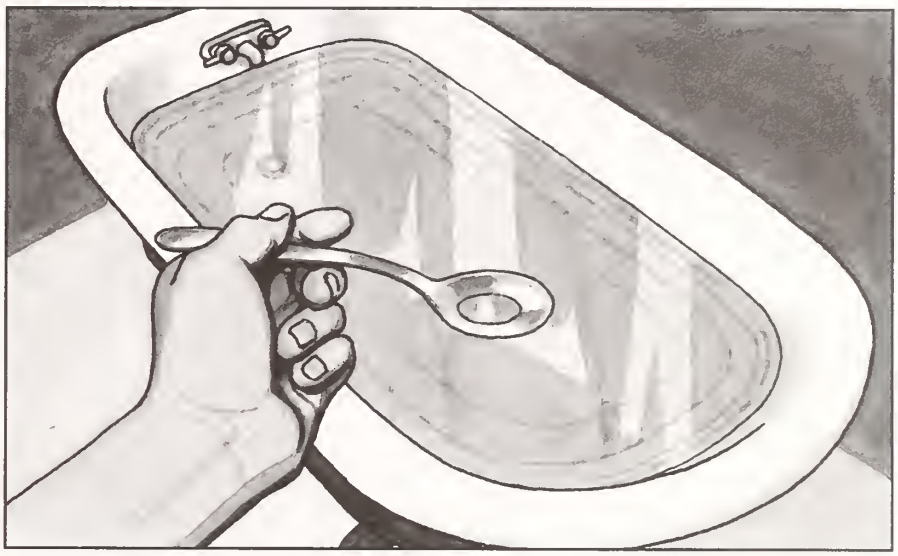
flows from its source—such as a river or well—through pipes to water treatment plants where it is cleaned. From the water treatment plant, it moves through pipes to our residences and industries. After use, water must be treated before it is released into a river or other water source.

Communities can suffer water shortages because of drought or sudden increases in population growth. Building larger water treatment plants (or in some areas, dams), desalinization facilities, or water diversion projects can increase a community's water supplies. However, these options are expensive and some communities cannot afford them. What can citizens do?

Wherever a community is located, citizens can use less water by implementing water conservation practices. However, before a water conservation program is put into practice, a water audit can provide excellent baseline data from which to measure the progress of the program.

An audit is one of the first steps to take along the path to water conservation knowledge and action. Just as a financial audit informs a person about the way he or she truly makes and spends money, a water audit quantifies the actual use of water in an informative way. Before we can take steps to solve problems, we need documented benchmarks to start from, and to measure our progress against.

Water audits are becoming a standard feature of long-range planning for industries, communities, and individuals. The findings are, without exception, illuminating; and they are often surprising. As the costs of providing water escalate, the importance of benchmark data and conservation strategies based on reliable figures also rises.



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Procedure

Warm Up

The *Conserve Water!* assessment is designed to determine if students understand the availability of fresh, potable water; the distribution of water on the planet; the cost of water (water and wastewater treatment); and the potential of water conservation measures to offset a community's increased water demands.

Distribute the assessment and allow students a few minutes to complete the form. Then, go through each question with students, discussing their responses and introducing information and concepts important for understanding the rationale for conducting a home or school water audit.

The Activity

1. Organize students into cooperative learning groups.
2. Have each group list all the ways they use water in a 24-hour period inside and outside their homes.
3. Record their ideas on the board.
4. Hand out the *Water Audit Data Sheet I* Student Copy Page to each student.
5. Ask students to review the sheet.
6. Ask them to record on the sheet in column A by each water use the number of times they believe they conduct that activity in a 24-hour period.
7. Instruct them to record the number of times they actually conduct each water use activity over the next 24 hours in column B of *Water Audit Data Sheet I.*
8. Have students compare the number of gallons they predicted with their actual use. Did they use more water than they guessed? Less? Were students surprised by the amount of water they used?
9. Ask students if they know of any ways to reduce the number of gallons of water they use. Do their parents frequently ask them to turn off the shower? Why? Is water free, just because it flows freely from the faucet?
10. Do students believe that using water resources wisely makes sense?
11. Ask students to suggest some water conservation practices.

12. **Hand out *Water Audit Data Sheet II* Student Copy Page.** Ask students to again record the amount of water they use in a 24-hour period, but this time they will implement as many water conservation practices as they can.
13. **Ask students to calculate the total amount of water they used in a 24-period when they were practicing water conservation measures.** Direct students to compare the total number of gallons on *Data Sheet I* to the total on *Data Sheet II.*

Wrap Up

Have students respond to the following questions related to water conservation practices:

- How did their water consumption change after implementing water conservation measures? How many gallons of water did they save? Were they more careful about their use of water after they realized how much they used?
- Which conservation measures were the easiest to institute?
- Which practices were the most difficult? Why?
- If you were only allowed 30 gallons of water per day, to what water uses would you give the highest priority?
- Select three of the water conservation practices that you found fairly easy to use. If you were to apply these three practices routinely, how many gallons of water would you save each month? If every member of your family consistently employed these practices, how many gallons would be saved per month within your own household?
- Is it a good idea for a school, business, or hospital to conduct a water audit? Why would a water audit be beneficial for these institutions?

Have students write a set of at least five recommendations or suggestions for their family based on their home water audit. These suggestions should include short- and long-term actions. For example, for long-term actions, students may suggest that low-flow showerheads be installed or water-saving appliances purchased when the current ones no longer function. Have students share their recommendations with the class.

Assessment

Have students:

- indicate their responses on the *Conserve Water!* assessment form *(Warm Up).*
- complete *Water Audit Data Sheet I* in order to calculate how much water they use in a 24-hour period (steps 6, 7, and 8).
- complete *Water Audit Data Sheet II* in order to compute how much water they use in a 24-hour period when they are implementing water conservation practices (steps 12 and 13).
- formulate a list of at least five recommendations for their family based on their home water audit *(Wrap Up).*

Extension

Although it is certainly more complicated, students may conduct a water audit of their school. Engage in this activity only after securing full permission from school administrators. The forms for a school water audit are included with this activity. Break the class into three audit teams as follows:

- Research and information team
- Indoor water use team
- Outdoor water use team

Hand out copies of the *Team Worksheets* Student Copy Pages and explain each team's job description (also explained on the worksheets) as follows:

- Reasearch and Information: To track down billing records; identify historic and yearly water use patterns; and conduct interviews with appropriate officials to pinpoint water use hot spots.
- Indoor water use: To document major indoor uses of water, pinpoint problem areas (leaks), and gather as much specific information as possible.
- Outdoor water use: To document major outdoor uses of water, pinpoint problem areas, and gather as much specific information as possible.

Set a deadline for when teams should have results (one week should be sufficient) and tell them when they will report their findings to the class.

Allow the class time to organize their approach to the tasks.

Be available to provide suggestions, assistance, or information during the audit process.

After the allotted audit time, regroup and ask one person from each team to present their findings to the class. Ask them to summarize their data, highlight the most obvious areas of concern, and list their conclusions pertaining to the school's use of water.

Once all the teams have reported, reconfigure the groups. Each of the new teams should have representatives from all three original teams.

Tell students that the point of all their initial work was to provide foundation information on which future policy and action can be based. The second phase of their work together is to formulate a set of strategic suggestions

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to present to school officials; their job is to aid in developing a comprehensive, school-wide water conservation program.

Give the new teams a class period (30-50 minutes) to work through the *Strategy Sheet* Student Copy Page, pooling their collective information.

When the groups finish, ask for a spokesperson from each to present the basic elements of their strategic suggestions.

Tell students that they've now gone through the essential steps of a basic audit, and they've come to some conclusion as a result. The next phase is to organize their data and suggestions in a concise, factual, and persuasive statement.

As a class, fill out a single, final Strategy Sheet, combining the best and most practical information from their audit process, along with a summary of the best strategy suggestions.

If it can be arranged, invite school officials to hear the class's final report and summary in a formal presentation. Alternatively, the class could send a delegation to meet with school officials and make a presentation.

Resources

Angelo, Thomas A., and K. Patricia Cross. 1993. *Classroom Assessment Techniques.* San Francisco: Jossey-Bass Publishers.

Johnson, Cynthia. *Water Ways.* 1997. Florida: Office of Public Instruction, St. Johns River Water Management District.

The Milk River Alliance. 2003. "Water Supply and Distribution." In *The Milk River: International Lifeline of the Hi-Line, A Guidebook.* Havre, MT: The Milk River Alliance. 9-11.

The Watercourse. 1999. *Conserve Water* Student Booklet. Bozeman, MT: The Watercourse.

The Watercourse. 1999. *Project WET Curriculum and Activity Guide.* Bozeman, MT: The Watercourse.

Conserve Water!

This is not a test, so it is okay to answer "I don't know." After you complete these questions, you and the other students will have a discussion with your teacher guided by your responses. This is a tool to help you learn more about water conservation.

1. Where does the water come from that flows out of your faucet at home?
    a. Home well
    b. Flows through pipes from city water treatment facility
    c. Directly from the river or ocean
    d. I don't know

2. Is water that flows out of your faucet at home free of charge?
    a. Yes
    b. No
    c. I don't know

3. Where does water go after it is flushed down the toilet or swirls down the drain in your home?
    a. To the city wastewater treatment plant
    b. Directly to the river
    c. Through the home septic system
    d. I don't know

4. If a bathtub full of water represents all the water in the world, what measurement below shows the amount of water in the world that is fresh, usable water?
    a. One cup of water
    b. One bathtub full of water
    c. One-half teaspoon of water
    d. One bucket of water

5. What percentage of the human body do you believe is made up of water?
    a. 50%
    b. 10%
    c. 70%
    d. 5%

6. Why are some places in the world dry and others very wet? That is, why is water distributed unevenly throughout the world?
    a. Some places just waste a lot of water, so it is dry
    b. Because of differences in weather, climate, and geography
    c. In some places, the sun never sets, so it is always hot and dry
    d. I don't know

7. Do you believe it is possible for individuals to change their habits and use less water? Do you think that individuals choosing to use less water can have a positive impact on the water supplies of their community? (Write 2 to 3 sentences to answer this question.)

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Water Audit Data Sheet I - Home Water Audit

Water Use	Column A Predicted # of water uses per day	Column B Actual # of water uses per day		Column D Actual # of gallons used per day (BxC=D)
Brush teeth for two minutes, water running			6 gallons	
One toilet flush			5 to 7 gallons	
Wash dishes by hand, rinse in running water			20 gallons	
Shower			5 gallons/ minute	
One dishwasher cycle			12 to 15 gallons	
Bath			30 gallons	
Wash hands, water running			3 gallons	
One clothes washing cycle			50 gallons	
Get a drink with water running			1/4 gallon	
Water lawn, 10 minutes			75 gallons	
Wash car with hose running			10 gallons/ minute	
				TOTAL:

1. Write down any other water uses that are not listed. Research to find out how many gallons of water that use requires.
2. Think of how often you directly use water every day. Write down how times you think you conduct a particular activity each day in column A.
3. Throughout the following day (as soon as you get up in the morning) record how many times you actually use water.
4. Multiply the number of times you use water by how many gallons each use generally requires.
5. Add all the numbers in column D.
6. Write your answer in the last box in column D. This is the estimated number of gallons of water you use every day.

Water Audit Data Sheet II - Home Water Audit

Water Use	Column A Water Conservation Action	Column B # of water uses per day	Column C Estimated # of gal. per use		Column D Actual # of gallons used per day (BxC=D)
			Without conservation action	With conservation action	
Brush teeth for two minutes, water running	Brush and rinse, water not running		6 gal	1/2 gal.	
One toilet flush	Low-flush toilet		5 to 7 gal.	3 gal.	
Wash dishes by hand, rinse in running water	Wash dishes and dip in pan of water to rinse		20 gal.	5 gal.	
Shower, water running	5 minutes with low-flow showerhead		*5 gal./ min.	12 gal.	
One dishwasher cycle			12-15 gal.		
Bath			30 gal.		
Wash hands, water running	Turning off water between wash and rinse		3 gal.	1/2 gal.	
One clothes washing cycle	Adjusted water level		50 gal.	25 gal.	
Get a drink with water running	Pour glass from water pitcher in 'fridge		1/4 gal.	1/16 gal.	
Water lawn, 10 minutes			75 gal.		
Wash car with hose running	Use bucket, sponge, and controlled-flow nozzle		**10 gal./ min.	5 gal.	
					TOTAL:

*5 gal. x length of shower in minutes = total water use
**10 gal. x number of minutes hose is running = total

1. Write down any other water uses that are not listed.
2. Conduct your daily water activities, but think of ways in which you could conserve water. Several suggestions are listed in the chart, but you may contribute any ideas you have and estimate your water saving.
3. Add up the total number of gallons in column D.
4. Compare the total number of gallons in column D with the number of gallons you used on Water Audit Data Sheet I.
5. How many gallons did you save in one day by practicing a few simple water conservation actions?
6. How many gallons would your family save in one day if everyone participated in these water conservation actions?
7. How many gallons would your family save in one month?

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Team Worksheet - Research and Information

Your role in the audit is to conduct research and interviews to document your school's water use figures and establish general water use patterns.

1. Identify the offices and individuals responsible for handling water at your school (fiscal manager, accountant, maintenance department, building manager). Contact these offices for an interview appointment with the people who have direct knowledge or information about the school's water use.
2. See if you can obtain copies of water bills and meter readings over the past year (longer if possible). Analyze them for times of peak and low use and any other obvious patterns.
3. Through meter readings and interviews, try to identify the major water users at the school (pool, sprinkler system, gym showers, bathrooms) and times of peak demand.
4. Find out if school officials have a way of itemizing water use for different parts of the school (separate meters are the most reliable way to do this).
5. Either from actual figures or interview information list your school's top five uses of water.

_____

_____

_____

_____

_____

6. In your interview (especially when you talk with people involved in the day-to-day use of water-pool maintenance, lawn watering, etc.) ask specific questions like:
   - What are the top water consumption activities at the school? On what information do you base the conclusion?
   - In what areas is water used most inefficiently?
   - Have you noticed specific water fixtures that leak persistently?
   - In your opinion, what measures could be taken to conserve water most effectively at school?
   - How could you more precisely document the school's water use?
7. Compare information from the various interviews to find common ground, and summarize your findings on a separate piece of paper.

Team Worksheet - Indoor Water Use

Your role is to survey the school buildings and document the major users of water. You will also search out leaks and other obvious problem areas.

1. Begin by touring the school buildings to take an inventory of water consuming fixtures/installations. As much as possible, document how much water each fixture uses. Cover at least the following:

Fixture/Installation Total	# Water Consumed/Used	
Indoor swimming pool		
Toilets/urinals		
Showers		
Drinking fountains		
Hot water heating pipes/AC		
Boiler		
Utility closets		
Bathroom sinks		
Indoor sprinkler system		

2. If you come across any leaky fixtures as you conduct the survey, do your best to measure the wasted water. Put a cup or jug under the leak and time it for one minute. Measure the amount of water, then multiply by 60 to get the amount lost every hour; multiply again by 24 to arrive at the daily total.
3. Identify fixtures that could be replaced with more efficient models (aerated faucets, low-flow showerheads, low-flow toilets) and multiply by the total number of fixtures.
4. Calculate several examples of the yearly savings that would result from some basic renovations. For example, how much water would be saved every year if the school fixed the leaks you found? If the school installed more efficient showerheads or low-flow toilets, how many gallons would be saved every 100 flushes or every 100 showers?
5. Are there too many water fixtures in some areas (drinking fountains, bathrooms)? Could the school reasonably do without some of these? Are the fixtures located in the best spots?
6. In general, what are the most intensive indoor uses of water at your school?
7. Are there other comments you would add after your tour? Other areas of concern you think would be worth investigating?

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Team Worksheet - Outdoor Water Use

Your role is to survey the school grounds and document the major uses of water. You will also search out leaks and other obvious problem areas. (During winter months in some climates students will have a hard time documenting some aspects of outdoor water use. They can still take their tour and make observations, but they will probably want to supplement their research with interviews with groundskeepers, maintenance staff, and so on.)

1. Start with a tour of the school grounds. Inventory all the obvious water-consuming devices. If possible, document how much water is used in each application. Likely outdoor water fixtures include:
   - Sprinkler systems
   - Outdoor pool
   - Fountains or ponds
   - Outside faucets
2. If possible, measure any leaks you find along the way by collecting water for one minute, multiplying by 60, and then again by 24 to arrive at the water lost every day.
3. Identify fixtures that could be made more efficient (drip irrigation, timers on sprinklers, covers for outdoor pools to reduce evaporation) and try to estimate the savings that might be achieved.
4. Consider other avenues of outdoor water conservation. For example, design a water-conservative landscape, plan a watering regime tied to times of day and climate conditions that minimize evaporative loss, adjust sprinkler heads so that water is not wasted by watering asphalt, and recirculate/reuse water for some applications. Write up a summary of your suggestions.
5. After your tour, list the top outdoor uses of water at the school and brainstorm suggestions to make conservation improvements in those areas.
6. Did you come up with other observations or insights you'd like to comment on? If so, address these on a separate sheet of paper.

Strategy Sheet

Now that you've gathered a quantity of raw data, you can draw some conclusions and make informed suggestions to your school. Pool the information collected by the three teams and use this form to summarize and direct your findings.

1. List the major uses of water at your school (the most dramatic and easily achieved results usually come from targeting the biggest water users).

Top Indoor Consumers	Top Outdoor Consumers

2. Briefly describe the leaks found by teams and list the three that are most serious.

3. How much water could your school save every year if they fixed every leak found by your group?

4. Based on your study of water bills, how much money would the school save by fixing all the leaks?

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Strategy Sheet, continued

5. What measures can you suggest that will have the most dramatic impact on water savings for your school?

   Indoor:

   Outdoor:

6. Come up with three to five concrete examples of water savings your school could achieve through simple measures or changes in practice (e.g., the installation of low-flow toilets or toilet dams would save the school 3 gallons/flush). If possible, give one or two examples of the potential financial savings that would accrue through lower water bills as a result of conservation. (For instance, if low-flow toilets saved 50,000 gallons/month, the school would pay X dollars less on the monthly water bill.)

   a. Water conservation measures:

   b. Financial savings that would result:

CFS ASAP

Grade Level:
Upper Elementary, Middle School

Subject Area:
Math, Earth Science

Duration:
Preparation Time: 50 minutes
Activity Time: 50 minutes

Setting:
Classroom, Gymnasium, or Outdoors

Skills:
Gather, Organize, Analyze, Interpret, Apply

Vocabulary:
cubic foot, cfs, flow

Summary

Students become a cubic foot of water (cfs) to demonstrate the concept of streamflow.

Objectives

Students will:

- describe the concept of cfs and how it is used.
- describe the volume and weight of a cubic foot of water.
- compare cfs to other forms of water measurement.

Materials

- Scrap cardboard
- Clear packing tape
- Two trash bags
- Water source
- Eight 1-gallon milk jugs with lids
- Rope to string milk jugs together
- Three 20-foot lengths of string/ rope or ten to twenty chairs (to simulate stream banks)
- Stopwatch
- Scale
- One copy of *CFS ASAP* Student Copy Page per student

Background

At some time students may have overheard their family or neighbors discussing the flow of the Milk River. Perhaps they heard the term "cfs" to describe the Milk's flow. This activity will help students grasp the concept of streamflow and how it is measured.

In the United States water flowing in streams and rivers is measured in cubic feet per second, commonly referred to as *cfs. Cfs is a measurement of how many cubic feet of water is moving past a point in a stream every second.* In Canada flowing water is measured in cubic meters per second or cms.

In order to effectively study and manage water in a stream, water managers must first accurately determine how much water is flowing. Historically, water managers collected cfs flow data by hand on a daily basis. Today, however, cfs data is typically collected at automated streamflow gages and hydromet stations located at various points along a river, and is then delivered electronically to websites and other data collection sites.

An understanding of the concept of cfs is important because much like a weatherman saying "it rained three quarters of an inch on Wednesday," a water manager can say, "the Milk River is flowing at 700 cfs today." Irrigators, municipal water managers, fish and wildlife managers, anglers and recreationists understand and depend on this information to make informed decisions about their activities.

Procedure

Warm Up

Part I (Construct beforehand)

Construct a cubic foot demonstration model from scrap cardboard. Draw five 12" x 12" squares on the pieces of cardboard. Carefully cut these squares out with a box knife and tape them together with clear packing tape to form a box with one open end. Reinforce the box with multiple wraps of tape to make it strong and solid.

Or if you have a piece of cardboard that is at least 3' by 3' square you can use the diagram on the following page to make a box.

Part II

1. **Without showing them the box, ask students to visualize one cubic foot.** Remind them that a cubic foot is a cube where all sides are twelve inches by twelve inches. Ask them to estimate how many gallons of water would fit in a cubic foot. How much would it weigh? Have them write their estimations on a piece of paper.

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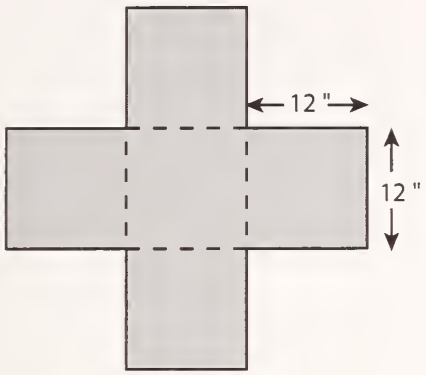
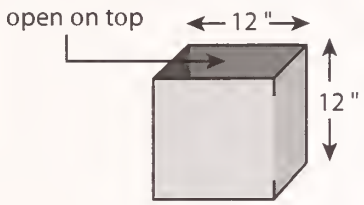
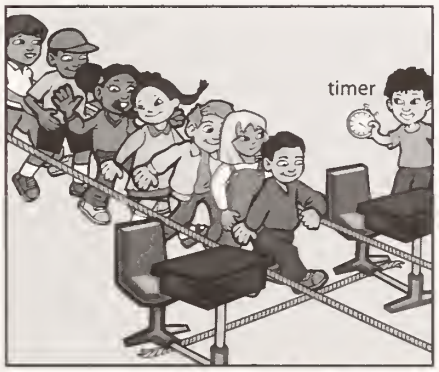




2. **Produce your model cubic foot and allow students to examine it. Have them reflect on their estimates for volume and weight. Would they like to adjust their estimations?**
3. **Have students test their estimates.** Line the cube with two trash bags. Have students use the gallon jugs to carefully fill the box to the top. It helps to do this outside or near a drain. Make sure they keep track of how much water they use. How much water fit in the cube? *A cubic foot of water is 7.48 gallons or 28.32 liters; students will probably have measured 7.5 gallons.* How does this compare to their estimates? Are they surprised by the results?
4. **Fill seven and one-half milk jugs with water (to represent one cubic foot). String a rope through the handles and have students try to lift the jugs.** Then have them weigh the jugs. How did this compare to their estimates for weight? *One gallon of water weighs 8.36 pounds. One cubic foot of water weighs 62.5 pounds.* Each of these hands-on manipulations will help students gain a physical understanding of a cubic foot of water.

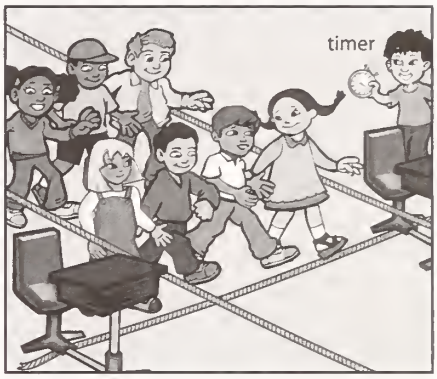
The Activity

1. **Explain that each student will "become" a cubic foot of water and travel downstream.**
   (Teacher's note—the following "Stream Scenarios" model a stream that is one-foot deep.)
2. **Stream Scenario 1, *Narrow Stream:* Have students "create" a narrow river using desks, rope or other objects as banks.** Lay a rope across the "stream" halfway down its length. Assign one student to time and record the activity. Have the rest of the students line up and "flow" single file "downstream" between the chairs. How many seconds did it take for everyone to pass over the rope? Timer should record the time while the remainder of the students help set up the stream for Scenario 2.



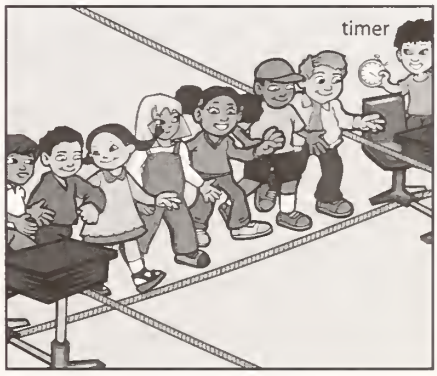
Stream Scenario 1, Narrow Stream.

3. **Stream Scenario 2, *Medium Stream:* Widen the simulated stream by moving the chairs or ropes back several feet.** Students should now be able to line up shoulder to shoulder approximately three or four abreast. Time them again as they walk downstream between the chairs over the rope. How many seconds did it take for them all to pass over the rope? Have the timer record information while students help set up Scenario 3.



Stream Scenario 2, Medium Stream.

4. **Scenario 3, *Wide Stream:* Widen the simulated stream enough that all students can stand shoulder to shoulder.** Time them again as they walk downstream between the chairs and over the rope. How many seconds did it take for them all to pass over the rope this time? (It should only take one second.) Again, have the timer record all information.



Stream Scenario 3, Wide Stream.

5. **Ask students to brainstorm other scenarios that can be measured.** Students may suggest running across the line to simulate a fast moving stream or making the stream deeper by carrying a student. Use your judgment and try some experiments. Record all data.

6. **Explain to students that they have demonstrated the concept of cubic feet per second (cfs).** The number of students crossing the line in the stream represents cfs, or cubic feet (of simulated water) crossing a line in one second. When water managers refer to cfs, they are discussing the amount of water (measured in cubic feet) passing a particular point at a particular time. For example, the cfs of the Milk River at Havre at 12:00 noon on June 3rd may be 500 cfs on an average year. Flood years and drought years would, typically, make this number be higher or lower respectively.
7. **Calculate the flow of water in cfs for each scenario using the student worksheet.** Hand out CFS ASAP Student Copy Sheets to each student. Have the timer report the times for each scenario to the class. Have students divide the number of students who "flowed" downstream by the number of seconds it took all of them to cross the line. This is the cubic feet per second (cfs) measurement of their stream. Have them record their answers.
8. **Have students use the conversion table at the bottom of the *CFS ASAP* Student Copy Page to calculate the cfs into other common units of measure, such as cubic meters per second, gallons per minute, liters per minute, acre-feet.** These units of measure are regularly used for agriculture, dam management and other water management applications. For example:

   Cubic meters per second measures streamflow in Canada and other metric countries.

   Gallons per minute measures flow volume of pumps and wells.

   Acre-feet equals the amount of water it takes to cover an acre of land one-foot deep and is commonly used to measure water for irrigation.
9. **(Optional)**The United States Geological Survey has a handy online cfs calculating tool at http://md.water.usgs.gov/cfscalc/ that makes cfs calculations a snap.

Wrap Up

Discuss the activity with students. What could change in each scenario to make the results different? What would happen if the river were deeper? What if the water were flowing faster? Why is it important to know the flow rate of a river? Who uses this information? Discuss answers.

Assessment

Have students:

- describe the concept of cfs and how it is used (step 6).
- describe the volume and weight of a cubic foot of water (*Warm Up* Part 2).
- compute cfs into other forms of flow measurement such as cubic meters per second or acre-feet (step 8).

Extensions:

Have students go to the following websites:

United States Geological Survey water website for Montana
http://mt.water.usgs.gov/

Alberta water information
http://www3.gov.ab.ca/env/water/Basins/Milk.html

Saskatchewan water information
http://www.saskwater.com

Have them find data from a stream gage near where they live. What is the cfs or cms today? Does the site contain historical water data? How are the sites different? How are they similar? Have students compare streamflows in different areas of the Milk River Watershed.

Have students interview a farmer or rancher and learn how much water particular irrigated crops need to grow. Have students research different methods of irrigation and compare their water use.

Resources:

Leopold, Luna B. *A View of the River.* 1994. Cambridge, MA: Harvard University Press.

The Milk River International Alliance. 2003. "Water Supply and Distribution." In *The Milk River: International Lifeline of the Hi-Line, A Guidebook.* Havre, MT: The Milk River International Alliance. 9-11.

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CFS ASAP

Calculate the cfs of each stream type using the formula below.

$$\frac{S}{T} = \text{cfs}$$

Stream Type	Number of students (s)	Number of Seconds (t)	Cubic Feet per Second (cfs)
1) Narrow Stream			
2) Medium Stream			
3) Wide Stream			
4) Other (specify)			
5)			
6)			

CFS Conversion Table

1 cfs =	
0.02832	Cubic meters per second
7.48	Gallons per second
448.8	Gallons per minute
26,928	Gallons per hour
646,272	Gallons per day
28.32	Liters of water per second
1,699.2	Liters of water per minute
101,952	Liters of water per hour
2,446,848	Liters of water per day
2.446848	Million liters of water per day
0.646272	Million gallons per day
0.000724637	Acre-feet

High and Dry

Grade Level:
Middle School, High School

Subject Areas:
Math, Earth Science, Geography, Language Arts, History

Duration:
Preparation Time: 50 minutes
Activity Time: 2 to 5 class periods

Setting:
Classroom, Library

Skills:
Gather, Organize, Analyze, Evaluate, Interpret, Present

Vocabulary:
cfs, hydrograph, water (hydrologic) cycle

Summary

Students will draw and interpret hydrographs of the Milk River.

Objectives

Students will:

- read and interpret a hydrograph.
- compare and contrast free-flowing and managed river systems.
- research hydrologic data on the Internet.

Materials

- One copy per student of *Free Flowing River* Student Copy Page
- One copy per student of Hydrograph A: North Fork of the Milk River above St. Mary's Canal (or use one copy as an overhead)
- One copy per student of Hydrograph B: Milk River at Eastern Crossing near International Boundary (West of Wild Horse, Alberta) (or use one copy as an overhead)
- One copy per student of black line map of Milk River Watershed (see centerfold of this book)
- Computers with Internet access

Background

The Milk River has a rich history of drought and flood. The greatest flood on record occurred in 1952 and was termed a "100-year flood." A "100-year flood" is one that occurs, on average, every 100 years. This name is a bit misleading however. Because they happen "on average" every 100 years they can occur back to back, or with several hundred years between them. Droughts occur more frequently than floods in the Milk River Watershed, and a "normal" year shows relatively low precipitation throughout much of the watershed. Comparing hydrographs and studying water flow helps students understand the runoff patterns of the Milk River and broadens their awareness of how weather, snowpack, dams, and irrigation affect its flows.

The United States Geological Service (USGS), the Bureau of Reclamation (BOR) and Sask Water of Canada, all keep water flow data for the Milk River. Data is collected at many sites in the watershed and then stored in on-line databases. The collected data show great flow variation both within a given year and from year to year. Though data sets are not complete for all years on all parts of the Milk River, there is plenty of online information available for students to analyze. This information is presented either in the form of numerical data sets or as hydrological graphs or hydrographs. For the purposes of this activity we will examine only hydrographs.

Hydrographs show the change in the amount of water flowing down a river over time. By using this visual representation of flow, students can quickly compare different rivers or the same river at different times of the year.

All graphed material is presented in cfs, or cubic feet per second. This term describes the volume (in one-foot by one-foot cubes) of water flowing past a given point every second. The USGS website listed in the Resources section of this activity provides sufficient data for students to compare the flow of the Milk River to that of other rivers in other watersheds in Montana.

Procedure

Warm Up

Hand out copies of *Free Flowing River* Student Copy Page. Have students plot hydrographs for high, average, and low water years on a hypothetical free-flowing river (a river with no dams). Have them plot each flow in a different color. How does such a hydrograph compare with one of the Milk River? A hydrograph taken from a point

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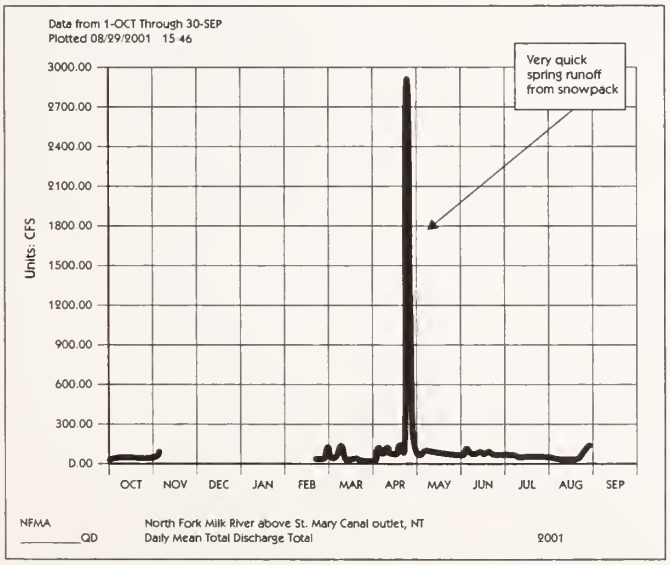
downstream of a reservoir and dam would not look like these. Why? What would it look like?

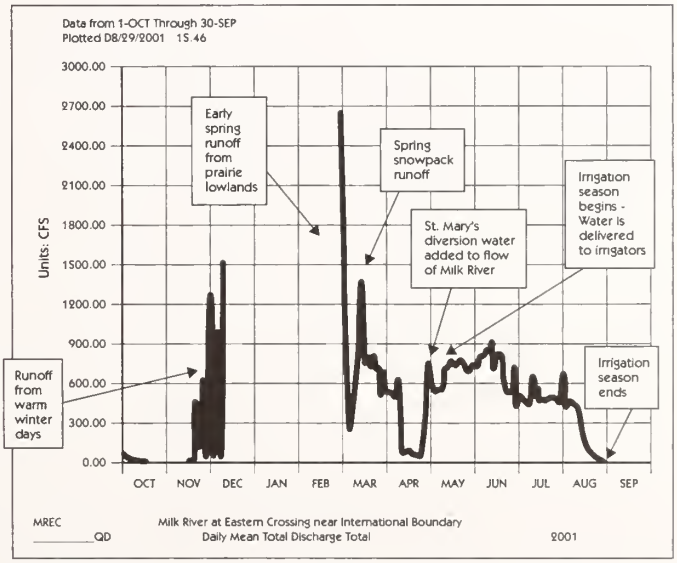
The Activity

Hand out copies of Hydrograph A: North Fork of the Milk River above St. Mary's Canal and Hydrograph B: Milk River at Eastern Crossing near International Boundary (West of Wild Horse, Alberta).

1. **Examine Hydrograph A: North Fork of Milk River above the St. Mary's Canal.** This hydrograph shows the North Fork of the Milk River sampled at a point before it flows through any reservoirs. Is this graph different or similar to the hydrograph of a free-flowing river? The hydrograph is quite similar. It shows very low flows most of the year with a sharp spike where spring runoff occurred.
2. **Examine Hydrograph B: Milk River at Eastern Crossing near International Boundary.** This hydrograph is completely different than the first. It shows the flow of water in the Milk River where it re-enters the United States west of Wild Horse, Alberta. In late February a spike (indicating melting prairie snow) rises to a peak of almost 2,700 cfs, then quickly drops again. A second spike in March marks higher elevation snowmelt and runoff into the Milk. By April melting snow from high in the mountains is being captured by upstream dams and stored in Lake Sherburne. Flows taper off to very low levels. Flows then rise again and generally stay between 600 and 900 CFS for the rest of the summer. What explains this? The increased flow comes from water being released from reservoirs and combining with water diverted from the St. Mary's River into the Milk. As the video *Milk River: Lifeline of the Hi-Line* illustrates, water from the St. Mary's is diverted at Lake Sherburne, then carried to the North Fork of the Milk through canals, siphons and concrete chutes (collectively called the St. Mary's Canal) which increases the flow of the Milk by 50-80%. This water is typically diverted in April and continues through September to provide for irrigation, municipal drinking water, and instreamflow for wildlife and recreation.
3. **Ask students to identify other interesting data on the hydrograph. What do they think causes the spikes of high flow in November and early December?** These spikes are caused by warm days that melt early season prairie snow. What happens to this water? Does it just wash downstream? No, it is captured and stored in Fresno Reservoir.
4. **Have students go to the Bureau of Reclamation hydromet station** site at http://www.gp.usbr.gov/hydromet/canalandstream.htm#mtao **to view a current Milk River hydrograph from an area near where they live.** Click on "QD Daily Mean Total Discharge (cfs)." How does this hydrograph compare to the examples above? Students can compare the current hydrograph for "North Fork of the Milk River above St. Mary's Canal" at http://www.gp.usbr.gov/htbin/hydromet_arcplt?NFMA&QD. Students can see the current



Hydrograph A: North Fork of the Milk River above St. Mary Canal.



Hydrograph B: Milk River at Eastern Crossing near International Boundary (West of Wild Horse, Alberta)

hydrograph for "Milk River at Eastern Crossing near International Boundary" http://www.gp.usbr.gov/htbin/hydromet_arcplt?MREC&QD.

5. **Have students go the USGS website for Montana Water at http://water.usgs.gov/mt/nwis/sw and find historical water data for the Milk River.** How can they make a hydrograph from this tabular data?
6. **Have students visit the Sask Water website at http://www.saskwater.com/hydrology/frenchman.htm and examine the hydrographs for the Frenchman/Battle/Lodge tributaries of the Milk River.** How might the flow of these tributaries affect the hydrographs downstream on the Milk? Does Canada record their data differently than the United States? Why? Have students multiply the cubic meters per second (written as m^3/s or cms) by 0.02832 to get flow in cubic feet per second.
7. **Using a copy of the map from the center of this book have students trace the route of a cubic foot of water through the Milk River system beginning in North Fork of the St. Mary's in the early spring and ending in the Missouri River below Nashua.** Where will it travel before it reaches the Missouri? Where is it stored? How do humans use it?

Wrap Up

Ask students to explain why it is important to collect and analyze streamflow data. How is this information used? Why is it helpful? Who uses it?

Have students describe the events that shape a hydrograph in the Milk River Basin such as spring snowmelt and irrigation season.

Assessment

Have students:

- interpret a hydrologic graph (steps 1-3).
- describe how a hydrograph from a free-flowing river differs from that of a managed river system (Warm Up).
- draw a hydrograph of a stream, river or canal near their home using data found on the Internet (steps 4-6).

Extensions

Invite a hydrologist to your classroom to discuss streamflow, flood and drought.

Assign students to interview people who lived through the 1952 flood, the 1986 floods and/or the 1988 drought. What memories are similar amongst those who survived the floods? Compile student interview notes to create a dramatic presentation of life in the Milk River Watershed. How did the drought of 2000-2002 affect students and their families? What stories can they tell about drought?

Have students write a hypothetical story of a water shortage or flood. Have them use a hydrograph to illustrate the story. Levels of cfs chosen by students should accurately reflect realistic flows for the Milk River system.

Discuss the Boundary Waters Treaty of 1909. The Treaty outlines principles and guidelines for the management of boundary and transboundary waters by Canada and the United States, with the primary objective of preventing or resolving disputes regarding the water quality and quantity of shared water resources. Was this treaty fair for people on the U.S. side of the Border? Why? Why not? Was it fair for people on the Canadian side of the border? Why? Why not? What were the benefits of the treaty? What were the costs? One benefit is a more consistent flow of water in the Milk for irrigators, especially in drought years. Costs might include the expense of the system and the difficulty of settling water disputes, especially in drought years.

Complete text of the International Boundary Waters Treaty Act can be found both at http://www.ijc.org/agree/water.html and http://laws.justice.gc.ca/en/I-17/text.html.

Resources

Bureau of Reclamation hydromet stations: http://www.gp.usbr.gov/hydromet/canalandstream.htm#mtao

The Milk River International Alliance. 2003. "Water Supply and Distribution." In T*he Milk River: International Lifeline of the Hi-Line, A Guidebook.* Havre, MT: The Milk River International Alliance. 9-11.

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Parrett, C. and J. A. Hull. 1990. Streamflow Characteristics of Small Tributaries of Rock Creek, Milk River Basin, Montana, Base Period Water Years 1983-1987. U.S. Geological Survey. No. 89-4206.

Sask Water Website: http://www.saskwater.com/htdocs/hydrogrf/#basin4

USGS Website: http://water.usgs.gov/mt/nwis/sw

See the current hydrograph for "North Fork of the Milk River above St. Mary's Canal" at http://www.gp.usbr.gov/htbin/hydromet_arcplt?NFMA&QD

See the current hydrograph for "Milk River at Eastern Crossing near International Boundary" at http://www.gp.usbr.gov/htbin/hydromet_arcplt?MREC&QD

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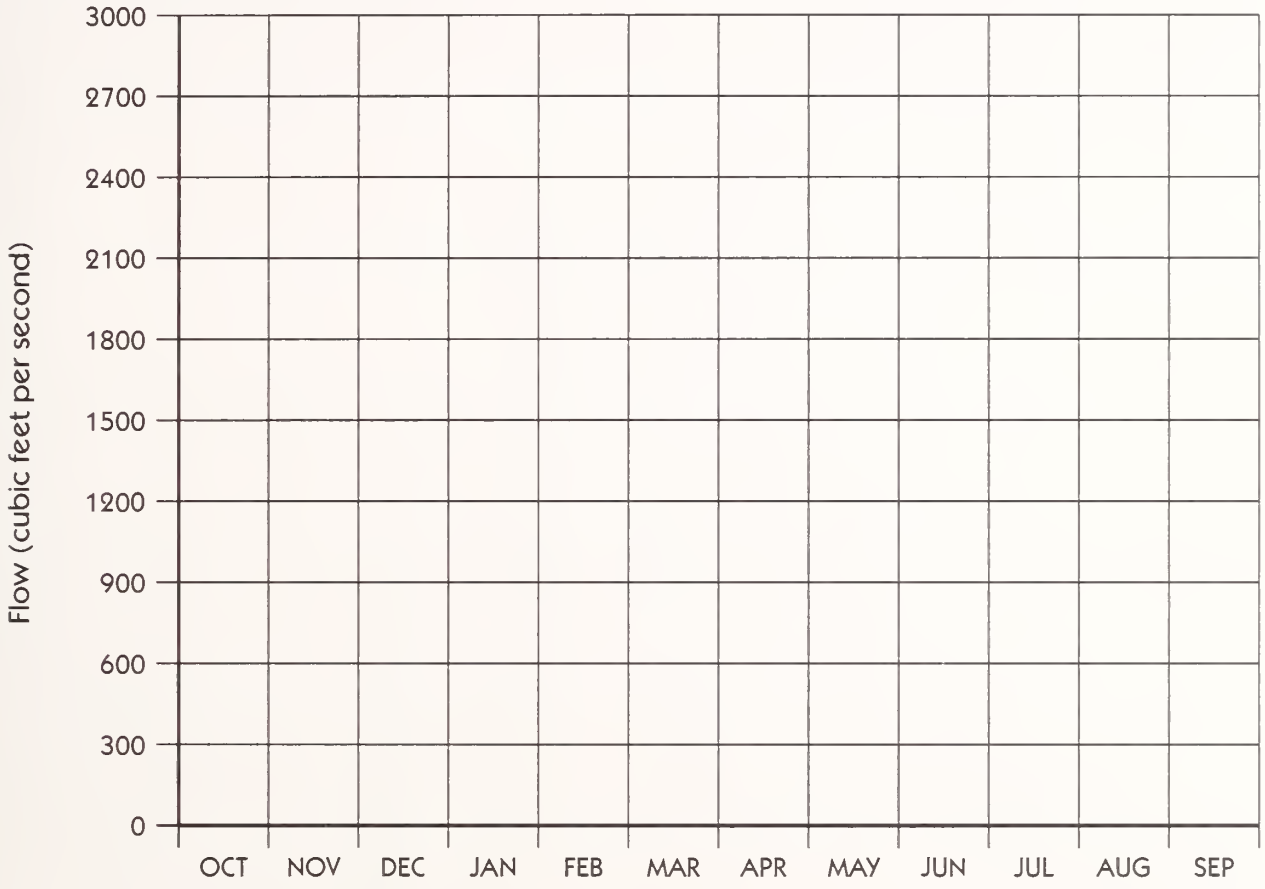
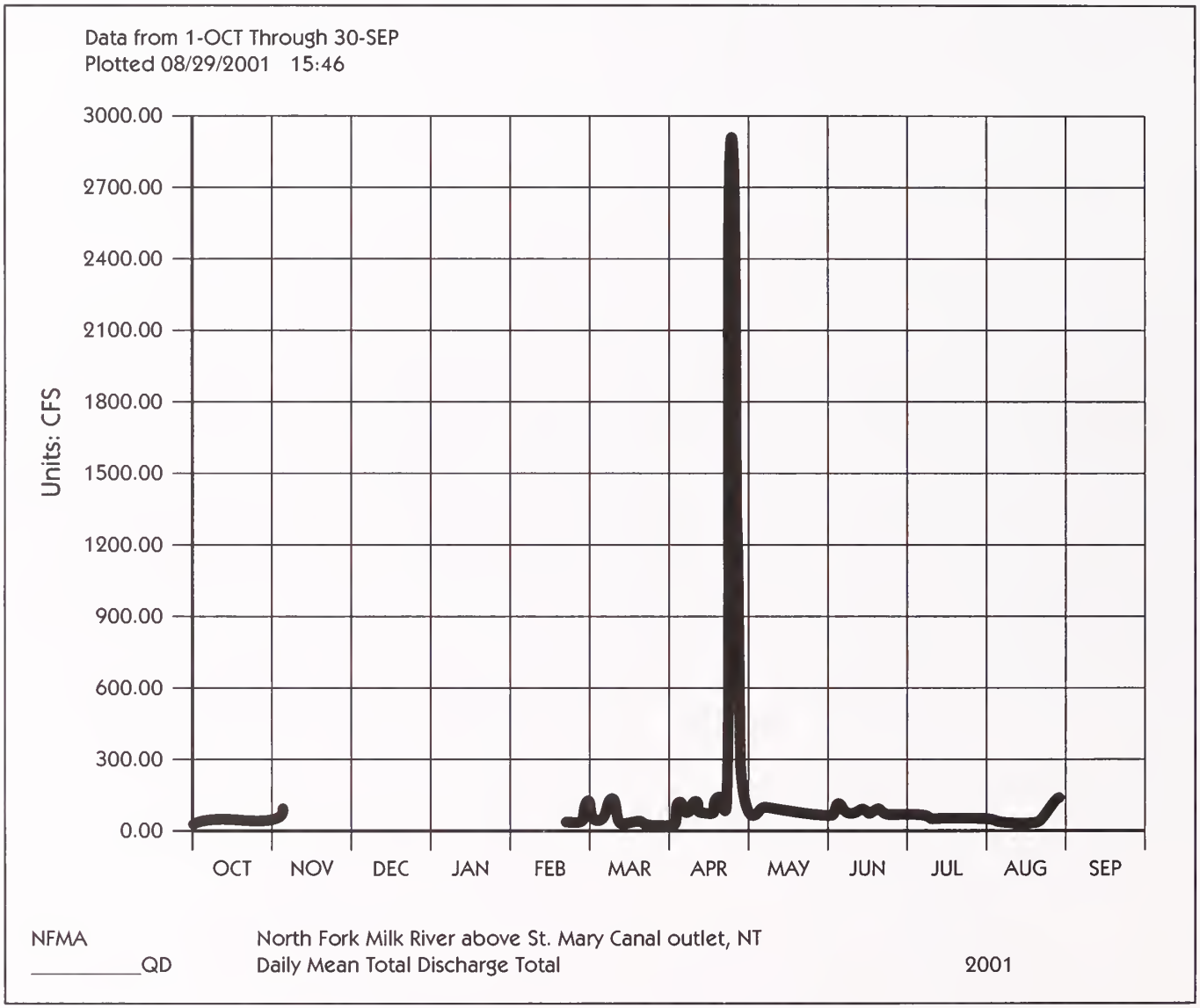
Free-Flowing River

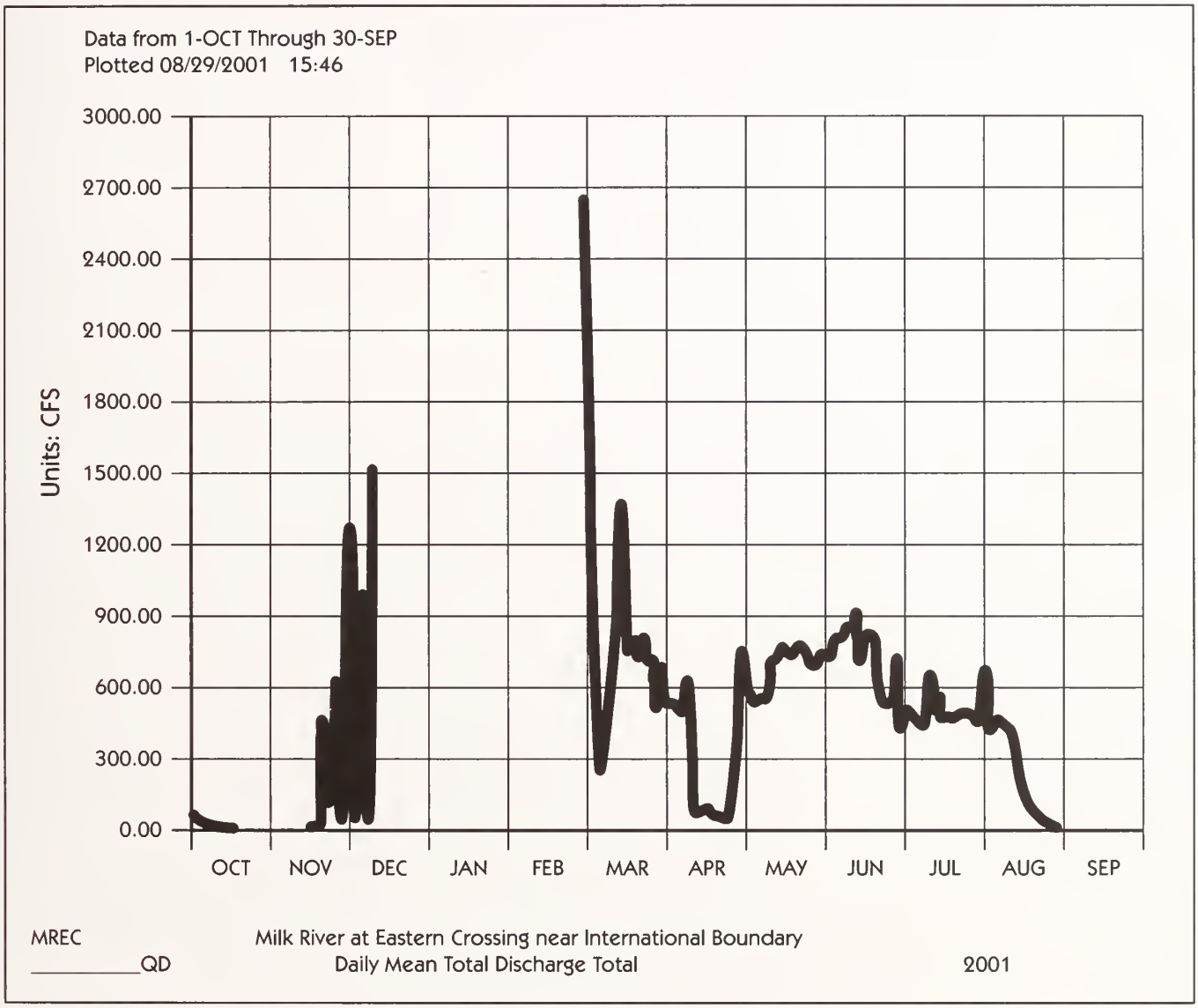


Month	Highest flow (CFS)	Average flow (CFS)	Lowest flow (CFS)
October	75	80	70
November	70	75	70
December	70	70	70
January	70	70	65
February	70	70	70
March	250	100	90
April	2000	1000	450
May	2250	2000	800
June	3000	2225	750
July	2225	1125	200
August	1000	800	100
September	200	85	70

Hydrograph A: North Fork of the Milk River above St. Mary's Canal



Hydrograph B: Milk River at Eastern Crossing near International Boundary (West of Wild Horse, Alberta)



Glossary

adaptation
The ability of a particular species to survive in a particular climate as a result of natural selection.

audit
A methodical examination and review.

average
(Also mean). A number that is intermediate between all numbers in that set. The average is calculated by dividing the sum of numbers, by the number of entries.

balance
To bring into harmony or proportion.

cfs
Cubic feet per second.
1) The amount of water that passes a given area in one second, measuring one foot by one foot.
2) The flow rate or discharge equal to one cubic foot of water per second or about 7.5 gallons per second.

characteristic
A distinguishing trait, quality, or property.

chronological order
Of, relating to, or arranged in or according to the order of time.

climate
Meteorological elements, including temperature, precipitation, and wind, that characterize the general conditions of the atmosphere over a period of time at any one place or region of Earth's surface.

climax
The most intense point in the development of a story.

confluence
A place where two or more rivers join.

conservation
The act of reducing or minimizing use of natural resources.

consumptive use
The use of a resource that reduces the supply (e.g., removing water from a source such as a river or lake without returning an equal amount). Examples are intake of water by plants, humans, and other animals and the incorporation of water into the products of industrial or food processing.

continental divide
A drainage divide separating the rivers flow toward opposite sides of a continent.

cooperation
The act of working in, or for, a common effort.

cost(s)
1) The amount or equivalent paid or charged for something.
2) The outlay or expenditure (as of effort or sacrifice) made to achieve an object.

cubic foot
A cube where all sides measure twelve inches by twelve inches.

deposition
The process of laying down sediment or accumulating layers of material carried in suspension.

desalinization
The process of removing salt from sea or brackish water.

drought
A period of long dryness that is often harmful to crops.

erosion
The wearing down or washing away of the soil and land surface by the action of water.

fauna
The animals that live in a given area.

flood
Any relatively high streamflow overtopping the natural or artificial banks of a stream.

flora
The plants that live in a given area.

flow
To issue or move in a stream.

glaciation
The process in which land is covered by an ice-sheet or by glaciers or is subject to glacial action or its result.

headwater(s)
The source of a stream. Typically there are many headwaters to a stream which flow together into the main body of the stream or river.

history
1) A chronological record of significant events often including an explanation of their causes.
2) A branch of knowledge that records and explains past events.

Homestead Act
An 1862 law that made lands available for free throughout much of the West.

hydrologic cycle
See water cycle.

hydrograph
A graphic plot of changes in the flow of water or in the elevation of water level plotted against time.

irrigation
The controlled application of water to cropland, hay fields and/or pasture to supplement that supplied by nature.

irrigation efficiency
The efficiency associated with acquiring water, delivering it to fields and applying it to crops. Efficiency is determined through a combination of factors including how much water is lost between the point of diversion and the point of use (mostly through evaporation and leaky ditches and pipes), the cost of delivering the water (mostly through equipment, energy, labor and other infrastructure costs), and how well the soil holds water once water is applied.

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migration
To move from one place or region to another.

nonconsumptive use
1) Instream use of water that does not reduce the supply.
2) Removing water and returning it to the source without reducing the supply (e.g., navigation and fisheries).

potable water
Water that is suitable, safe, or prepared for drinking.

retrofitting
To modify or update equipment.

riparian area(s)
Land area(s) directly influenced by a body of water; usually has visible vegetation or other physical characteristics showing this water influence. Quite simply, the area of vegetation that typically borders a stream.

sediment
Fragmented organic or inorganic material derived from the weathering of soil, alluvial, and rock materials; removed by erosion and transported by water, wind, ice and gravity.

setting
The location or time in which a story takes place.

settlement
To establish a residence.

snowpack
Seasonal accumulation of snow that normally melts slowly during the early summer months.

streamflow
The discharge of water that occurs in a stream channel.

timeline
A chronological list of important events within a particular historical period.

treaty
A formal agreement between two or more parties with regard to national or international relationships.

tributary
A stream that contributes its water to a stream or another body of water.

water allocation
The process of measuring a specific amount of water devoted to a given purpose in a hydrologic system in which there are multiple uses or demands for water.

water cycle
The paths water takes through its various states—vapor, liquid, and solid—as it moves throughout earth's systems (oceans, atmosphere, ground water, streams, etc.). Also known as the hydrologic cycle.

water diversion
The transfer of water from a stream, lake, aquifer, or other source of water by canal, pipe, well or other conduit to another watercourse or to application on the land.

water right
A legal right to use a specified amount of water for beneficial purposes.

watershed
A land area from which water drains toward a common watercourse in a natural basin. It is a land feature that can be identified by tracing a line along the highest elevations between two areas on a map, often a ridge. Large watersheds may contain thousands of smaller watersheds.

Glossary Sources

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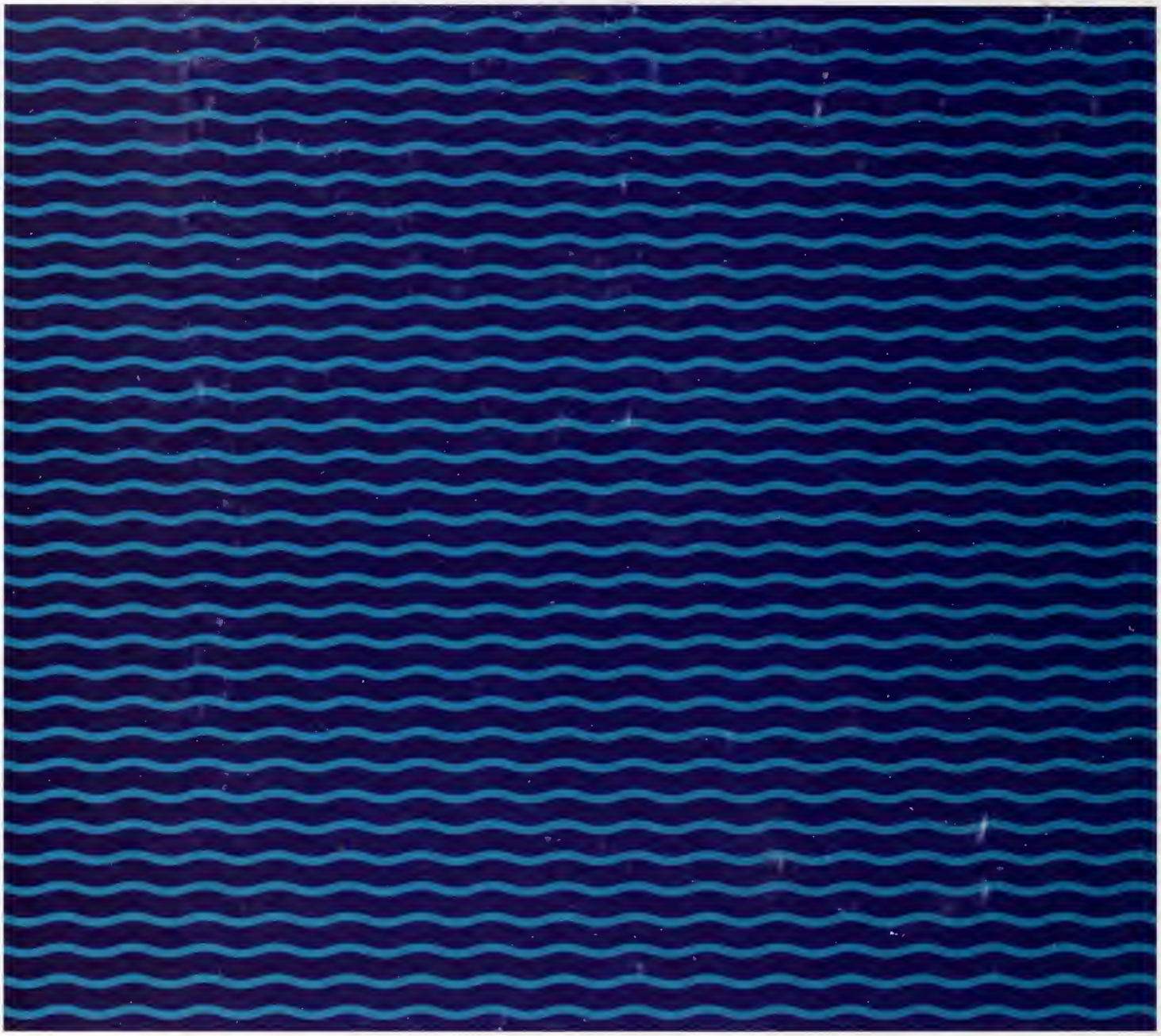
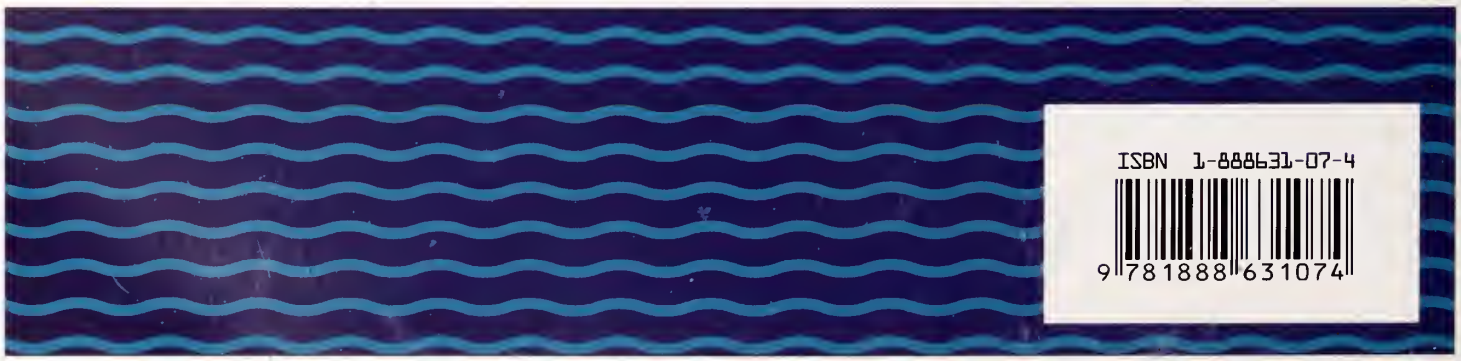


Milk River
International
Alliance



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